W. B. No. 666

U. S. DEPARTMENT OF AGRICULTURE
WEATHER BUREAU
CHARLES F. MARVIN, Chief

MONTHLY WEATHER REVIEW

VOLUME 46, No. 10

OCTOBER, 1918

WASHINGTON
GOVERNMENT PRINTING OFFICE
1918

OCTOBER, 1918.

CONTENTS.

NOTICE TO CONTRIBUTORS.

Contributions intended for publication in any given issue of the MONTHLY WEATHER REVIEW (e. g., January) should be in the hands of the editor before the end of the next following month (e. g., February), if no illustrations are required. When the paper is illustrated, the manuscript and the copy for illustrations must be submitted much earlier, in order to permit copy being prepared for the engraver by the end of the month.

REPRINTS are made up without covers in the original size and pagination of the REVIEW. They will not be furnished unless specifically REQUESTED WHEN THE MANUSCRIPT IS SUBMITTED.

MONTHLY WEATHER REVIEW

HERBERT H. KIMBALL, Acting Editor.
CHARLES F. BROOKS, Associate Editor.

Vol. 46, No. 10.
W. B. No. 666.

OCTOBER, 1918.

Closed Dec. 3, 1918.
Issued Jan. 7, 1919.

INTRODUCTION.

As explained in this introduction during 1914, the Monthly Weather Review now takes the place of the Bulletin of the Mount Weather Observatory and of the voluminous publication of the climatological service of the Weather Bureau. The Monthly Weather Review contains contributions from the research staff of the Weather Bureau and also special contributions of a general character in any branch of meteorology and climatology.

Supplements to the Monthly Weather Review are published from time to time.

The climatological service of the Weather Bureau is maintained in all its essential features, but its publications, so far as they relate to purely local conditions, are incorporated in the monthly reports "Climatological Data" for the respective States, Territories, and colonies.

Since August, 1915, the material for the Monthly Weather Review has been prepared and classified in accordance with the following sections:

Section 1.—*Aerology.*—Data and discussions relative to the free atmosphere.

Section 2.—*General meteorology.*—Special contributions by any competent student bearing on any branch of meteorology and climatology, theoretical or otherwise.

Section 3.—*Forecasts and general conditions of the atmosphere.*

Section 4.—*Rivers and floods.*

Section 5.—*Seismology.*—Results of observations by Weather Bureau observers and others as reported to the Washington office.

Section 6.—*Bibliography.*—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

Section 7.—*Weather of the month.*—Summary of local weather conditions; climatological data from regular Weather Bureau stations; tables of accumulated and excessive precipitation; data furnished by the Canadian Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto; Meteorological Summary and chart No. 9 of the North Atlantic Ocean for this month in 1917. Owing to the fact that ocean meteorological data are frequently not available for a considerable time after the close of the month to which they relate, the chart and text matter in connection therewith appear one year late.

In general, appropriate officials prepare the seven sections above enumerated; but *all students of atmospherics are cordially invited to contribute such additional articles as seem to be of value.*

The voluminous tables of data and text relative to local climatological conditions, that during recent years were prepared by the 12 respective "district editors," are omitted from the Monthly Weather Review, but are collected and published by States at selected section centers. (See cover, p. 3.)

The data needed in Section 7 can only be collected and prepared several weeks after the close of the month designated on the title-page; hence the Review as a whole can issue from the press only within about eight weeks from the end of that month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are due especially to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.
The Meteorological Service of Cuba.
The Meteorological Observatory of Belen College, Habana.
The Government Meteorological Office of Jamaica.
The Meteorological Service of the Azores.
The Meteorological Office, London.
The Danish Meteorological Institute.
The Physical Central Observatory, Petrograd.
The Philippine Weather Bureau.

The Weather Bureau desires that the Monthly Weather Review shall be a medium of publication for contributions within its field, but such publications is not to be construed as official approval of the views expressed.

Circulation of the Monthly Weather Review:

Foreign, about 315 copies.
Domestic, about 1,100 copies.

SECTION I.—AEROLOGY.

SOLAR AND SKY RADIATION MEASUREMENTS DURING OCTOBER, 1918.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Weather Bureau, Washington, Nov. 30, 1918.]

For a description of instrumental exposures, and an account of the methods of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1918, **46**:2.

The monthly means and departures from normal values given in Table 1 show that direct solar radiation averaged slightly below its normal intensity at Washington, D. C., and Lincoln, Nebr., and above normal at Madison, Wis. No measurements were obtained at Santa Fe, N. Mex., on account of a broken suspension in the galvanometer.

Table 3 shows only slight departures from the normal radiation for the month at Washington and Madison, although both these stations and also Lincoln, show a deficiency for the third decade. At Madison this deficiency amounted to 34 per cent of the decade normal, and at Lincoln to 25 per cent. The deficiency for the month at Lincoln was about 10 per cent.

Skylight polarization measurements obtained on six days at Washington give a mean of 60 per cent, with a maximum of 64 per cent on the 22d. These values are very close to October averages for Washington. Measurements obtained on nine days at Madison give a mean of 64 per cent with a maximum of 69 per cent on the 9th.

TABLE 1.—*Solar radiation intensities during October, 1918.*

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Oct. 1		1.14								
4		0.97	0.94	0.77	0.68	0.60	0.53			
8		1.26	1.23	1.16	1.09	1.03	0.97	0.93	0.88	0.82
9							0.87			
10		1.15	0.94		0.75	0.70	0.65			
11				0.72						
14			1.16	1.09	1.02	0.93	0.86	0.79	0.73	
15			1.22	1.13	1.03	0.97	0.90	0.86	0.83	0.80
16			1.21	1.09	0.99	0.89	0.84	0.80	0.76	0.71
19			1.10	1.03	0.96	0.95	0.91	0.81		
21		1.32	1.16	1.04		0.74	0.67	0.62	0.57	0.52
22			1.36			1.08	1.07	1.07	0.98	
31				0.98						0.84
Monthly means		**1.17**	**1.15**	**1.00**	**0.93**	**0.88**	**0.83**	**0.84**	**0.79**	**0.74**
Departure from 10-year normal		**−0.06**	**+0.03**	**−0.02**	**±0.00**	**+0.01**	**+0.01**	**+0.06**	**+0.02**	**±0.00**
P. M.										
Oct. 1		1.01	0.85							
2		1.08	0.98	0.89	0.81	0.74	0.68	0.63	0.58	
8			1.13	1.04	0.97	0.82	0.77	0.73	0.69	
13		1.26								
15		1.15	0.86	0.76	0.67					
21				1.12						
22		1.27	1.24	1.13	1.09	1.04	1.01	0.92	0.84	
Monthly means		**1.15**	**1.01**	**0.99**	**0.88**	**0.87**	**0.82**	**0.76**	**0.70**	
Departure from 10-year normal		**−0.08**	**−0.11**	**−0.03**	**−0.03**	**+0.04**	**+0.05**	**+0.04**	**+0.02**	

TABLE 1.—*Solar radiation intensities during October, 1918*—Contd.

[Gram-calories per minute per square centimeter of normal surface.]

Madison, Wis.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Oct. 5		1.33	1.19							
9	[*1.45]		1.25	1.16	1.09	1.01				
12		1.27								
21				1.30	1.26	1.18	1.12	1.07		
25				1.27	1.17	1.08	1.04	0.96	0.93	0.89
Monthly means		**(1.30)**	**(1.22)**	**1.24**	**1.17**	**1.09**	**(1.08)**	**(1.02)**	**(0.93)**	**(0.89)**
Departure from 9-year normal		**+0.05**	**+0.06**	**+0.14**	**+0.13**	**+0.14**	**+0.21**	**+0.27**	**+0.26**	**+0.23**
P. M.										
Oct. 3		1.29	1.21	1.15	1.07	0.99				
7			1.08							
12			1.20	1.08						
25			1.29	1.18	1.11	0.94				
Monthly means		**(1.29)**	**1.20**	**1.14**	**(1.09)**	**(0.96)**				
Departure from 9-year normal		**−0.02**	**+0.04**	**+0.04**	**+0.08**	**−0.01**				
Lincoln, Nebr.										
A. M.										
Oct. 5		1.39	1.25	1.16	1.08	1.00				
8	[*1.41]	1.28	1.16	1.06	0.96	0.89	0.82	0.75		
13	[*1.48]	1.38	1.29							
14		1.36	1.27	1.21	1.14	1.07	1.02	0.90		
28			1.27							
29					1.12	1.07				
30			1.37	1.30	1.22	1.15			1.01	
Monthly means		**1.35**	**1.27**	**1.18**	**1.10**	**1.04**	**(0.92)**	**(0.82)**	**(1.01)**	
Departure from 4-year normal		**−0.01**	**−0.04**	**−0.05**	**−0.05**	**−0.02**	**−0.09**	**−0.11**	**+0.09**	
P. M.										
Oct. 5			1.27		1.10	1.03	0.98	0.93	0.86	0.82
13				1.20	1.12	1.04	0.97	0.91	0.87	0.83
14			1.27	1.16	1.05	0.95	0.87	0.78		0.69
Monthly means			**(1.27)**	**(1.18)**	**1.09**	**1.01**	**0.94**	**0.87**	**(0.86)**	**0.78**
Departure from 4-year normal			**+0.02**	**+0.02**	**+0.01**	**−0.02**	**−0.03**	**−0.04**	**±0.00**	**−0.05**

* Extrapolated, and reduced to mean solar distance.

TABLE 2.—*Vapor pressures at pyrheliometric stations on days when solar radiation intensities were measured.*

Washington, D. C.			Madison, Wis.			Lincoln, Nebr.		
Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.
1918.	*mm.*	*mm.*	1918.	*mm.*	*mm.*	1918.	*mm.*	*mm.*
Oct. 1	6.27	7.04	Oct. 3	5.36	4.57	Oct. 5	9.47	7.57
2	8.48	14.10	5	9.14	6.76	8	9.83	7.29
4	6.50	9.14	7	6.50	6.76	13	5.79	5.26
8	5.36	5.56	9	7.04	7.29	14	4.75	6.27
9	6.02	7.87	12	12.24	10.59	28	3.45	6.76
10	7.57	9.14	21	5.16	3.30	29	3.45	7.04
11	7.57	11.38	25	4.37	5.56	30	3.81	5.56
13	10.97	9.47						
14	6.27	4.95						
15	5.36	6.27						
16	6.02	8.81						
19	5.16	6.27						
21	7.57	4.75						
22	4.57	4.75						
31	9.83	13.61						

TABLE 3.—*Daily totals and departures of solar and sky radiation during October, 1918.*

[Gram—calories per square centimeter of horizontal surface.]

Day of month.	Daily totals.			Departures from normal.			Excess or deficiency since first of month.		
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Oct. 1	384	225	312	44	−63	−58	44	−63	−58
2	389	379	305	53	94	−62	97	31	−120
3	320	362	375	−12	81	11	85	112	−109
4	380	209	212	51	−69	−149	136	43	−258
5	319	375	459	−6	100	101	130	143	−157
6	277	284	406	−45	13	52	85	156	−105
7	182	373	374	−137	105	24	−52	261	−81
8	424	92	411	108	−172	65	56	89	−16
9	322	373	328	9	112	−14	65	201	−30
10	388	270	138	78	13	−200	143	214	−230
11	277	62	211	−30	−192	−123	113	22	−353
12	124	339	410	−180	89	80	−67	111	−273
13	358	285	432	57	38	106	−10	149	−167
14	299	289	428	1	45	106	−9	194	−61
15	354	302	390	59	61	72	50	255	11
16	365	281	360	72	43	46	122	298	57
17	314	286	324	24	51	14	146	349	71
18	198	304	94	−90	72	−212	56	421	−141
19	389	90	106	103	−139	−196	159	282	−337
20	79	334	362	−204	108	64	−45	390	−273
Decade departure							−188	176	−43

TABLE 3.—*Daily totals and departures of solar and sky radiation during October, 1918*—Continued.

[Gram—calories per square centimeter of horizontal surface.]

Day of month.	Daily totals.			Departures from normal.			Excess or deficiency since first of month.		
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Oct. 21	376	285	248	95	62	−46	50	452	−319
22	371	153	135	92	−67	−155	142	385	−474
23	307	218	191	31	1	−95	173	386	−569
24	249	48	379	−25	−166	97	148	220	−472
25	170	302	43	−102	91	−235	46	311	−707
26	191	43	29	−79	−165	−246	−33	146	−953
27	234	42	27	−34	−164	−245	−67	−18	−1,198
28	208	115	288	−58	−88	19	−125	−106	−1,179
29	201	53	363	−63	−148	97	−188	−254	−1,082
30	102	113	292	−160	−85	29	−348	−339	−1,053
31	187	140	288	−73	−56	28	−421	−395	−1,025
Decade departure							−376	−785	−752
Excess or deficiency since first of year: gr.-cal.							−2,774	+509	−135
Excess or deficiency since first of year: per cent.							−2.4	+0.5	−0.1

HALO PHENOMENA OBSERVED DURING OCTOBER, 1918.

By WILLIS RAY GREGG, Meteorologist.

Station.	Altitude.	Latitude.	Longitude.	Date.	Form observed.	Time of— Beginning.	Time of— Ending.	Theodolite readings. Time.	Radius inside.	Radius outside.	Length of arc.	Distance from sun or moon.	Altitude of sun or moon.
	m.	° ′	° ′						°	°	°	°	°
*Broken Arrow, Okla	233	36 02	95 49	16	Solar halo, 22°	7:00 a. m.	4:34 p. m.	7:24 a. m.	22.5	23	180		9.5
				20	Lunar halo, 22°	8:30 p. m.	11:30 p. m.						
				21	Solar halo, 22°	12:00 m.	3:45 p. m.	12:52 p. m.	22	23	360		42
Canton, N. Y	137	44 36	75 10	4	Solar halo, 22°	2:45 p. m.	3:20 p. m.						
				9	Solar halo, 22°	7:50 a. m.	8:40 a. m.						
				15	Solar halo, 22°	12:05 p. m.	12:45 p. m.						
				15	Parhelion, right, 22°.	12:05 p. m.	12:45 p. m.						
				16	Solar halo, 22°	2:00 p. m.	2:35 p. m.						
				16	Lunar halo, 22°	7:45 p. m.	8:45 p. m.						
				22	Lunar halo, 22°	8:00 p. m.	10:00 p. m.						
				23	Lunar halo, 22°	6:00 a. m.	6:30 a. m.						
				23	Solar halo, 22°	10:00 a. m.	10:20 a. m.						
Cincinnati, Ohio	191	39 06	84 30	10	Solar halo, 22°	2:30 p. m.	2:50 p. m.						
				10	Parhelion, right, 22°.	2:24 p. m.	2:32 p. m.						
				10	Parhelion, left, 22°.	2:24 p. m.	2:32 p. m.						
				17	Solar halo, 22°	12:15 p. m.	1:45 p. m.						
				17	Lunar halo, 22°	5:35 p. m.	9:00 p. m.						
				22	Solar halo, 22°	12:45 p. m.	1:45 p. m.						
				29	Solar halo, 22°	11:00 a. m.	11:25 a. m.						
Dayton, Ohio	274	39 46	84 10	5	Solar halo, 22°	11:40 a. m.	1:15 p. m.						
				11	Solar halo, 22°	8:00 a. m.	8:40 a. m.						
				17	Solar halo, 22°	10:40 a. m.	12:30 p. m.						
				22	Solar halo, 22°	12:00 m.	12:30 p. m.						
				29	Solar halo, 22°	11:00 a. m.	11:40 a. m.						
*Drexel, Nebr	396	41 20	96 16	2	Solar halo, 22°	9:30 a. m.	12:45 p. m.	9:45 a. m.	22	22.5	260		34
				7	Solar halo, 22°	12:12 p. m.	1:00 p. m.	12:37 p. m.	22	22.5	200		44
				9	Solar halo, 22°	11:35 a. m.	3:30 p. m.	2:20 p. m.	22	22.5	300		35
				15	Lunar halo, 22°	6:30 p. m.	7:45 p. m.	7:00 p. m.	22	23	260		35
				17	Solar halo, 22°	11:35 a. m.	2:30 p. m.	11:50 a. m.	22	22.5	320		39
				24	Solar halo, 22°	8:00 a. m.	8:38 a. m.	8:18 a. m.	23	24.5	180		16
				28	Solar halo, 22°	2:40 p. m.	3:21 p. m.	2:47 p. m.	22	22.5	120		24
				28	Circumhorizontal arc.	2:40 p. m.	3:21 p. m.	2:47 p. m.			10	46	24
*Ellendale, N. Dak	444	45 59	98 34	4	Solar halo, 22°	3:00 p. m.	3:15 p. m.						
				11	Solar halo, 22°	3:30 p. m.	4:35 p. m.	3:45 p. m.	21.8	22.6	220		21.5
				17–18	Lunar halo, 22°	9:57 p. m.	2:22 a. m.				360		
*Groesbeck, Tex	141	31 30	96 28	19	Solar halo, 22°	4:28 p. m.	4:46 p. m.						
				20	Lunar halo, 22°	11:00 p. m.							
*Leesburg, Ga	85	31 47	84 14	15	Solar halo, 22°	3:00 p. m.	3:50 p. m.						
				17	Lunar halo, 22°	6:40 p. m.	9:00 p. m.		22		360		
				18	Lunar halo, 22°	7:00 p. m.	7:30 p. m.						
				23	Solar halo, 22°	9:00 a. m.	9:20 a. m.						
				27	Solar halo, 22°	12:30 p. m.	1:30 p. m.						
Madison, Wis	297	43 05	89 23	1	Solar halo, 22°								
				4	Solar halo, 22°	10:30 a. m.	12:00 m.						
				10	Solar halo, 22°	11:30 a. m.	1:00 p. m.						
				10	Parhelion, right, 22°.	6:46 a. m.	9:00 a. m.						
				10	Parhelion, left, 22°.	6:46 a. m.	9:00 a. m.						
				10	Solar halo, 22°	3:44 p. m.	3:55 p. m.						
				10	Solar halo, 46°	3:44 p. m.	3:50 p. m.						
				15	Parhelion, right, 22°.	4:00 p. m.	4:30 p. m.						
				16	Solar halo, 22°	9:30 a. m.	10:00 a. m.						
				18	Solar halo, 22°	10:50 a. m.	5:00 p. m.						
				19	Lunar halo, 22°	4:30 a. m.	5:00 a. m.						
				22	Lunar halo, 22°	D. N. a.	6:05 a. m.						
				22	Solar halo, 22°	1:00 p. m.	2:00 p. m.						
				29	Solar halo, 22°	7:50 a. m.	8:00 a. m.						
Nashville, Tenn	166	36 10	86 47	None.									
*Royal Center, Ind	225	40 53	86 29	10	Solar halo, 22°	7:57 a. m.	1:50 p. m.						

* Aerological station.

Halo phenomena observed during October, 1918—Continued.

Station.	Date.	Colors.†	Degree of brightness.	Clouds.			Station pressure.	Precipitation.	
				Amount.	Kind.	Direction.		Last previous ended.	First subsequent began.
* Broken Arrow, Okla	16	O	Dim	3	A. St.	s.	Stationary	2:45 p. m., 12th	10:30 a. m., 17th.
	20	O	Bright	9	Ci. St.	w.	Stationary	4:10 p. m., 19th	5:50 a. m., 22d.
	21	R	Dim	9	A. St.	sw.	Falling	4:10 p. m., 19th	5:50 a. m., 22d.
Canton, N. Y	4	O	Dim	2	Ci. St.	w.	Rising	D. N., a., 3d	D. N., a., 5th.
	9	O	Dim	4	Ci. St.	w.	Falling	11:40 a. m., 6th	D. N., a., 11th.
	15		Dim	6	A. St.	w.	Falling	7:37 a. m., 13th	5:10 p. m., 17th.
	15		Dim						
	16	O	Dim	2	Ci.	w.	Falling	7:37 a. m., 13th	5:10 p. m., 17th.
	16	O	Dim	4	Ci. St.	w.	Stationary	7:37 a. m., 13th	5:10 p. m., 17th.
	22	O	Bright	4	Ci. St.	w.	Stationary	8:40 p. m., 20th	D. N. a., 25th.
	23	O	Dim	3	Ci. St.	w.	Stationary	8:40 p. m., 20th	D. N., a., 25th.
	23	O	Dim	1	Ci. St.	w.	Stationary	8:40p. m., 20th	D. N., a., 25th.
Cincinnati, Ohio	10	R, O, Y	Dim	4	Ci. St.	w.	Stationary	D. N. p., 5th	2:53 p. m., 11th.
	10	R, O, Y	Dim						
	10	R, O, Y	Dim						
	17	R, O, Y	Dim	9	Ci. St.	sw.	Falling	6:10 a. m., 12th	12:34 p. m., 19th.
	17		Bright	10	A. St.	sw.	Stationary	6:10 a. m., 12th	12:34 p. m., 19th.
	22	R, O	Dim	9	Ci. St.	nw.	Falling	2:40 p. m., 20th	3:00 p. m., 23d.
	29	R, O, Y, G	Bright	10	A. St.	sw.	Falling	D. N., a., 28th	5:00 a. m., 30th.
Dayton, Ohio	5		Bright	8	Ci. St.	w.	Falling	8:50 p. m., 30th	6:35 p. m., 5th.
	11		Dim	9	Ci. St.	w.	Stationary	9:10 p. m., 5th	2:45 p. m., 11th.
	17	R	Bright	9	Ci. St.	w.	Falling	D. N., a., 12th	2:10 p. m., 19th.
	22		Dim	7	Ci. St.	w.	Stationary	9:35 a. m., 20th	8:15 p. m., 23d.
	29		Bright	9	Ci. St.	sw.	Falling	3:55 a. m., 28th	D. N., a., 30th.
* Drexel, Nebr	2	R, G	Dim	7	Ci. St.	w.	Rising	6:00 a. m., 1st	5:47 p. m., 2d.
	7	R, O, Y, G, B	Dim	8	Ci. St.	sw.	Falling	3:15 a. m., 5th	D. N., a., 10th.
	9	R, O, Y, G, B	Dim	10	Ci. St.	wsw.	Falling	3:15 a. m., 5th	D. N., a., 10th.
	15		Dim	5 4	Ci. St. A. St.	w. w.	Rising	9:00 a. m., 11th.	4:18 p. m., 18th.
	17	R, O, Y, G, B	Dim	6 2	Ci. St. A. St.	w. w.	Stationary	9:00 a. m., 11th.	4:18 p. m., 18th.
	24	O	Dim	3 4	Ci. Ci. St.	sw. sw.	Rising	D. N., a., 23d	12:47 p. m., 25th.
	28	R, O, Y, G, B	Dim	5 4	Ci. St. A. Cu.	ssw. wsw.	Rising	D. N., p., 27th	1:12 p. m., 30th.
	28	R, O, Y, G, B	Dim						
* Ellendale, N. Dak	4		Dim	7 2	Ci. St. A. Cu.	sw. wnw.	Falling	5:15 p. m., 2d	5:35 p. m., 4th.
	11	R	Bright	8	Ci. St.	w.	Stationary	5:43 p. m., 4th	7:50 p. m., 18th.
	17-18	R	Bright	10	Ci.	w.	Stationary	5:43 p. m., 4th	7:50 p. m., 18th.
* Groesbeck, Tex	19							1:27 p. m., 16th.	4:04 p. m., 21st.
	20							1:27 a. m., 16th.	4:04 p. m., 21st.
* Leesburg, Ga	15		Dim	9	Ci. St.	(?)	Rising	D. N., a., 15th	D. N., a., 16th.
	17		Dim	10	A. St.	(?)		D. N., p., 17th	D. N., a., 18th.
	18		Dim	5 4	Cu. St. Cu.	e. e.	Rising	12:45 p. m., 18th.	6:07 a. m., 19th.
	23		Dim	10	A. St.	(?)	Rising	8:10 a. m., 22d	2:57 p. m., 23d.
	27		Dim	Few 8	Ci. St. Cu.	(?) se.	Stationary	D. N., a., 26th	3:19 p. m., 28th.
Madison, Wis	1	R	Bright	9	Ci. St.	w.	Falling	2:15 p. m., 29th.	3:50 a. m., 4th.
	4	R	Bright	10	Ci. St.	w.	Falling	4:25 a. m., 4th	2:25 a. m., 8th.
	10	R	Bright	10	Ci. St.	w.	Stationary	5:00 p.m., 8th	1:00 a. m., 11th.
	10		Bright	9	Ci. St.	w.			
	10		Bright						
	10	R	Bright	10	Ci. St.	w.			
	10		Dim						
	15		Brilliant	2	Ci. St.	nw.	Stationary	5:00 p. m., 11th.	5:00 p. m., 19th.
	16		Dim	8	Ci. St.	w.	Stationary	5:00 p. m., 11th.	5:00 p. m., 19th.
	18						Stationary	5:00 p. m., 11th.	5:00 p. m., 19th.
	19	R	Bright	10	Ci. St.	w.	Falling	5:00 p. m., 11th.	5:00 p. m., 19th.
	22		Dim	10	Ci. St.	w.	Stationary	9:50 p. m., 19th.	1:30 a. m., 23d.
	22			6 4	Ci. St. A. St.	w. w.	Stationary	9:50 p. m., 19th.	1:30 a. m., 23d.
	29	R	Bright	10	Ci. St.	w.		9:00 a. m., 28th.	9:00 a. m., 29th.
Nashville, Tenn	None.								
* Royal Center, Ind	10	R, B	Dim	9	Ci. St.	w.	Falling	1:15 a. m., 9th	10:06 a. m., 11th.

* Aerological station. † Beginning with part nearest sun or moon. R, red; O, orange, etc.

FORECAST SERVICE FOR AVIATORS BEGINS.

On December 1, the aerological data obtained from pilot balloon and kite flights late in the afternoon were telegraphed to the central office of the Weather Bureau from 18 Signal Corps and Weather Bureau aerological stations in the eastern United States. From these data, the first forecast for the New York to Chicago aeroplane mail service was made and telegraphed to Cleveland. The scope of these bulletins for aviators has been outlined by the Chief of the Weather Bureau as follows:

It is expected that the bulletins will contain a brief statement of (1) current conditions along selected routes, this statement to include (*a*) the direction and speed of the wind at different altitudes; (*b*) altitudes of cloud layers, when these are below 4 kilometers; (*c*) altitudes at which the greatest help will be given by the winds, or the least resistance will be offered by them, in case opposing winds will be encountered at all altitudes; (2) a forecast of probable changes in conditions during the succeeding 24 hours.

In a recent letter to the Secretary of Agriculture the Second Assistant Postmaster General says:

The extension of the aerial mail service this coming spring contemplates a direct air line from Boston to New York, New York to Washington, Washington to Atlanta, Atlanta to Tampa, Tampa to Key West; also New York to Cleveland, Cleveland to Chicago, Chicago to Omaha, Omaha to Denver; also south to St. Louis, St. Louis to Kansas City; also Chicago to Milwaukee, Milwaukee to St. Paul and Minneapolis. The bulletin should cover the disturbed areas over these lines.—*Ed.*

SECTION II.—GENERAL METEOROLOGY.

A MUCH NEEDED CHANGE OF EMPHASIS IN METEOROLOGICAL RESEARCH.

By PROF. WILLIAM S. FRANKLIN, Massachusetts Institute of Technology.

[Presented before Washington Academy of Sciences, June 7, 1918.]

Meteorology is generally conceded to be the least advanced of all the physical sciences. While considerable advances have been made in forecasting based on telegraphed information, forecasting from observations at a single station is but little better than has been possible for a thousand years among weatherwise farmers. And not even a definite scientific conception of the possibility of weather control has hitherto existed. These are very important phases of meteorology, weather prediction, and weather control, and it is no wonder that many laboratory physicists who do predict and control should have a contempt for meteorological studies, and especially for those of statistical character. Also, in view of the wonderful developments in laboratory physics, it is natural that many meteorologists should be more or less apologetic in their attitude toward their work. It seems, however, to the author that contempt for statistical studies on the part of the laboratory physicist is wholly unjustifiable, and very certainly no meteorologist should take an apologetic attitude toward his chosen line of work.

One object of this paper is to show that the ordinary point of view of the laboratory physicist is extremely narrow and his disapproval of statistical studies not to be taken very seriously. Another object is to convince the meteorologist that he has been too much imbued with the older point of view of the laboratory physicist, and still another object which is, in fact, the chief object of the paper, is to set forth a new point of view, which is beginning to develop among laboratory physicists, a point of view which may be expected to lead to a very great increase of interest in the use of the statistical method. Indeed it seems probable, in the author's opinion, that statistical studies may come to be as alluring as the classical physics.

The most remarkable thing concerning the older methods in the physical sciences is that every measurement, every laboratory study, is and must be made in a region in equilibrium, in thermal equilibrium more or less nearly complete. The older physics is the study of permanencies,[1] as explained in the following pages. Actual movements in nature, actual happenings, things which do occur, have never been the immediate objects of study by the physicist or chemist. If an actual movement presents a dominant state of permanency, like the motion of the earth in its orbit, this dominant state of permanency is abstracted from the complex movement as a whole and treated by the well-known method of mechanics. If an actual movement presents a state of quasi equilibrium, like the slow saponification of an oil in an alkaline solution, this state of quasi equilibrium is abstracted from the complex movement as a whole (the solution may be violently agitated for example) and studied as a chemical reaction velocity. If we study a steady flow (approximately steady flow) of heat, we arrive, by more or less abstraction, at the quantitative laws of heat conduction and emission. In every case in which quantitative correlations are established in the laboratory the experimental system is brought more or less completely under control to a state of permanency. For example, we take a batch of gas and bottle it up and protect it from outside disturbances by thick layers of cotton or wool, we use a long-stemmed thermometer to measure its temperature, and we change its volume with extreme slowness and make measurements of corresponding temperatures, pressures, and volumes, and it is not surprising that we find a very definite correlation between temperature, pressure, and volume of such a quiet body of gas.[2] Let it be understood that we are not here concerned with the fact that Boyle's law, for example, is not exactly true, but we are concerned with the fact that there is a definite relation between the pressure and volume of a given body of gas at a given temperature. The mathematicians call such a relation a one-to-one correspondence.

All of the classical laws of physics are one-to-one correspondences; they relate always to substances or systems in permanent states; they are approximate only[3] when they refer to quasi permanence, and the essential narrowness of the classical method in physics and chemistry has never been more strikingly pointed out than by Goethe, who, being a poet, could not be expected to recognize the necessity or appreciate the tremendous practical importance of any narrow and prosaic point of view.

> "Wer will was Lebendiges erkennen und beschreiben
> Sucht erst den Geist heraus zu treiben."

Whoever undertakes to study things seeks at the beginning to drive the spirit out. To make any detailed chemical study of wood, even of dead wood, one must crush it and cook it and by dissolution reduce it to one or more homogeneous substances. In studying any complicated chemical phenomenon one must limit oneself to what may be called, in mild derision, the "before" and "after" method,[4] comparing the quiet initial state of a system with its quiet final state, and one makes a discovery if one establishes a relation between associated changes which take place in two systems.[5]

---

[1] The reader will be very greatly helped in getting a clear idea of what is here referred to if he will look up a simple discussion of the mechanical notion of force which is given on pages 322-323 of Franklin and McNutt's General Physics, McGraw-Hill Book Co., New York, 1916. This discussion is an exposition of some of the simpler ideas which are set forth in a remarkable article by Sir Joseph Larmor "On the Scope of Mechanical Explanation." The present paper must be kept within readable limits, and the author considers it necessary to supplement the paper by references, which may help definitely and clearly to accomplish his object. The article by Sir Joseph Larmor is very difficult to read, and it would be useless for any reader of moderate mathematical attainments to attempt to read it.

[2] It is a common mistake to think of the classical laws of physics as *inexact* when they are merely *not simple* from the arithmetical or algebraic point of view. The pressure of a body of oxygen at a fixed temperature is not exactly in inverse proportion to the volume, but for each volume there is a perfectly definite pressure, perfectly definite if one has a sufficiently large body of oxygen, if it is sufficiently protected from outside disturbances, and if measurements of volume and pressure are taken so as to refer to the average behavior of the gas over a very long interval of time, as long as a few thousandth's of a second, let us say.

[3] Or when the experimental system is very small or the measurements taken too quickly. The atomic theory suggests that this qualification applies to every kind of one-to-one correspondence in nature and careful observation has verified this suggestion in a few instances.

[4] See outline of boiler test under the heading "Thermodynamics and the atomic theory."

[5] The ideas of energy and entropy have to do wholly with associated changes in separate systems, and however strongly inclined the reader may be to think of energy "as the only real thing in the universe," the author insists that to understand this paper one must adopt the naive point of view that physically real things are simply the things that we see and feel. Precise ideas (mathematical ideas) are tremendously important in that they open the mind for the perception of the simplest evidences of a subject, as Whewell has said, * * * provided the evidences are consistent with the ideas. Accepted ideas close the mind almost completely to contrary evidences. Ideas help tremendously to form our sense of physical things * * * but they inhibit sense as well. This matter is discussed in a very naive manner in the introduction, pages 1-15, of Franklin and McNutt's Mechanics and Heat, Franklin and Charles, Bethlehem, Pa., 1910.

Errors of measurement—Probable errors and probable departures.

It has long been the custom to speak of the probable error of a precise measurement as if perfect precision would be possible if our measuring devices were perfect and free from erratic variations. It is important, however, to recognize two distinct types of erratic error, namely, extrinsic error due to uncontrollable variability of the measuring device or system and intrinsic error due to inherent variability of the thing or system which is being measured. Every physical measurement involves an operation of congruence, a standard of some kind is fitted to or made congruent with successive parts (which parts are thereby judged to be equal parts) of the thing or system which is being measured; and the standard system and the measured system are both subject to erratic variations.

There is, perhaps, no case in which intrinsic error and extrinsic error can be clearly distinguished and separated from each other; but when the errors of one kind are much larger than the errors of the other kind, they can, of course, be recognized. It is proper to speak of the *probable error* of a single measurement when the variations of the measuring device or system are dominant, but one should speak of the *probable departure* of the measured system from a certain expected condition at any time when the "errors" of observation are due chiefly to variability of the thing or system which is being measured. Thus, in measuring the coefficient of sliding friction extrinsic error may be made negligible by making the measurements carefully, but very large "errors" persist. The thing which is being measured is inherently indefinite, and it may at any time depart widely from the most carefully considered expectation.[6]

Hydraulics as illustrating the method of mechanics.

Hydraulics is the study of fluids in motion, and the phenomena of fluid motion are to the careful observer excessively complicated. Even the apparently steady flow of a river through a smooth sandy channel is an endlessly intricate combination of boiling and whirling motion; and a jet of spray from a hydrant or a burst of steam from the safety valve of a locomotive, what is to be said of such things as these? Or let one consider the fitful motion of the wind as indicated by the swaying of trees and the quivering of leaves and as actually visible in driven clouds of dust and smoke, or the sweep of flames in conflagration. These are actual examples of fluid motion and they are indescribably, infinitely,[7] complicated.

The science of hydraulics is based upon ideas which relate to average aspects of fluid motion. Thus the engineer is concerned chiefly with such things as the time required to draw a pail of water from a hydrant, the loss of pressure in a line of pipe between a pump and a fire nozzle, or the force exerted by a water jet upon the buckets of a water wheel. These things are never perfectly steady but they are always subject to perceptible fluctuations of an erratic character, and to think of any one of these effects as definitely quantitative is of course to think of its average character under the given conditions; and the extent to which the science of hydraulics is limited by the consideration of average effects is evident from the following outline of the fundamental idea of simple flow.

When water flows steadily through a pipe or channel the motion is always complicated more or less by continually changing eddies; the water at a given point does not continue to move in a fixed direction at a constant velocity. Nevertheless it is convenient to treat the motion as if the velocity of the water were in a fixed direction and of constant magnitude at each point. Such ideal fluid motion is called simple flow, and to use the idea of simple flow in the study of an actual case of fluid motion is the same thing as to consider the average character of the motion during a fairly long interval of time. Also to make use of the idea of lamellar flow in the study of pipes and channels is to consider the average velocity over the entire section of the pipe or channel.

A gardener is not concerned with the size or shape of a particular drop of rain or whether it falls on the north or south side of a particular clod of earth—all such erratic details are to him of no consequence; but the erratic movements of a fluid are not always unimportant as the experienced seaman and especially the experienced aviator knows too well, and where individual cases of erratic behavior are important the classical method in physics is somewhat limited in its usefulness. Indeed the use of the classical method tends to divert one's attention away from erratic happenings, however important they may be.

Thermodynamics and the atomic theory.

In nearly every branch of physical science there are two more or less distinct methods of attack, namely, (*a*) a method of attack in which the effort is made to develop mechanistic conceptions or models of physical and chemical processes, and (*b*) a method of attack in which the effort is made to correlate phenomena on the basis of measured data; and these two methods stand out in sharpest contrast in the study of heat phenomena. The first method is the application of the *atomic theory* and the second method is called *thermodynamics*.

The atomic theory is used in every branch of physics but to develop the contrast between the atomic theory and thermodynamics we will limit our discussion to the subject of heat (which properly includes the whole of chemistry). Every student of elementary chemistry is familiar with some of the uses of the atomic theory. What happens when carbon burns, for example? Two atoms of oxygen fall upon an atom of carbon and form a molecule of CO_2, which when formed is in violent agitation. Let the reader recall the well-known ideas; there is no need to dwell upon them here. But in the purely thermodynamic method one is not concerned with thermal and chemical actions themselves but with their results. Imagine an engineer squinting into a furnace and making a minute microscopic study of every flicker of flame and of every curl and puff of smoke. It is not done. The important and feasible thing in a boiler test is to study (1) the condition of the supply water from which the steam is made (2) the qualities of air and coal which are to combine in the furnace (3) the pressure and temperature of the steam which is to be produced, and (4) the quality and temperature of the flue gases as they enter the chimney. That is to say, it is important (and feasible) to consider

[6] We are here necessarily anticipating what is referred to later as the postulate of indeterminism.

[7] Everyone concedes the idea of infinity which is based on abstract number—one, two, three, four, and so on ad infinitum—and the idea of infinity which comes from the contemplation of a straight line. But most men are concerned with the humanly significant and more or less persistent phases of the material world; their perception does not penetrate into the substratum of erratic action which underlies every physical happening, and they balk at the suggestion that the phenomena of fluid motion, for example, are infinitely complicated. Surely the abstract idea of infinity is as nothing compared with the awful intimation of infinity that comes from things that are seen and felt.

only the state of things before and after the combustion takes place and the only measurements that are needed (and the only ones that are feasible or even thinkable) are measurements made of substances in approximate thermal equilibrium.

Systematic physics and statistical physics.

Helmholtz has used the term "systematik" to designate the classical methods in physics, which include the method of mechanics and the method of thermodynamics, and also the atomic theory when it is used, as it often is, to help in the establishment of one-to-one correspondences in systems in permanent or quasi-permanent states. Nearly the whole of physical science has been hitherto what Helmholtz called systematik, and the correlations which have been established are, nearly all of them, one-to-one correspondences, many of which are expressible to a fair degree of approximation in terms of very simple analytical functions.

We often extend the classical method in physics to systems which are very far removed from permanent states, but the ideas which are used and the kinds of correlations which are established are all borrowed from, and relate to ideal permanencies. We may, for example, determine to a certain rough degree of approximation how the members of a bridge structure stretch or shorten as a car passes across the bridge; how electromotive force, current strength, and all the changing variables play in the operation of a dynamo; how the pressure and temperature of the steam vary during the successive stages of admission, expansion, and exhaust of a steam engine; and so on. But all these things are accompanied by very perceptible amounts of erratic action. Everything which takes place in this world has associated with it a substratum of complex action which baffles description. Consider, for example, a simple thing like the movement of a train of cars. The engineer is concerned only with certain broad features of what takes place, the amount of coal and water used, the draw-bar pull of the locomotive, and the forward motion of the cars as affected by steepness of grade and the opposing force of friction. But who could describe in detail the rocking and rattling motion of the cars and the whirling and eddying motion of the surrounding air, and who could trace the motion of every particle of dust and smoke? This indescribably complex action we call by the name of *turbulence;* it exists everywhere and in everything that goes forward in this world of ours, and it is never twice alike in detail even when the conditions are what one would consider exactly the same. All of which suggests two postulates concerning turbulence, namely, (*a*) that it is infinitely complicated, and (*b*) that it is essentially erratic in character. Let it be understood, however, that we are not speaking in terms of ordinary ideas or values in making these two statements. It is not a question, for example, as to whether a brakeman loses his hat every time he makes a trip from Albany to Buffalo, but it is a question as to whether his hat is lost every time at identically the same place because of a gust of wind of precisely the same character when he lets go of it in the same way because of a sudden jerk of the train which always occurs at the same place in exactly the same manner, and so on in endless detail of specification, if such specification were possible.

In the motion of a simple mechanism like the sun and planets or in the operation of a simple machine like a dynamo the accompanying erratic action is practically negligible. Thus one does not consider even the tremendous storm movements in the sun in the study of planetary motion, and one does not consider the minute details of the motion which takes place in a lubricated bearing in the study of the operation of a dynamo. In many phenomena, however, erratic action is dominant. Consider, for example, the motion of the water in a brook. This motion presents a fairly definite average character at each point, and a fairly typical rythmic variation from this average exists at each point, but there is an erratic departure from this regular motion which is by no means negligible in magnitude. So it is in the case of the weather. There is a fairly definite average of weather conditions at a place from year to year, and a fairly typical rythmic variation, but there are, as we all know, wide departures from average and from type, departures which for the most part are erratic in character.

Turbulence is characteristic of those physical and chemical changes which are called irreversible or sweeping processes.[8] The most familiar example of such a process is ordinary fire, and, as every one knows, a fire is not dependent upon an external driving cause, but when once started it goes forward spontaneously and with a rush. Tyndall, in referring to the impetuous character of fire, says that it was one of the philosophical difficultues of the eighteenth century. A spark is sufficient to start a conflagration and the effect would seem to be out of all proportion greater than the cause. Herein lay the philosophical difficulty. This difficulty may seem to be the same as that which the biologist faces in thinking of the small beginnings of such a tremendous thing as the chestnut tree blight in the United States. The chance importation of a spore is indeed a small thing, but it is by no means an infinitesimal, whereas, under conceivable conditions a fire can be started by a cause more minute and more nearly insignificant than anything assignable.[9] This possibility of the growth of tremendous consequences out of a cause which has the mathematical character of an infinitesimal is the remarkable thing; and this possibility is not only characteristic of fire, but it is characteristic of impetuous processes in general.

The postulate of indeterminism.[10]

Impetuous processes, such as storm movements of the atmosphere are intimately connected with conditions of

[8] If the reader is not familiar with the fundamental ideas which are related to and involved in the second law of thermodynamics, and it is safe to assume that he is not, he might profitably read pages 153–169 of Franklin and McNutt's General Physics. This is an extremely simple and vividly physical discussion and it will serve to show how erratic action or turbulence is treated in the classical thermodynamics. This has, of course, an important bearing on the subject matter of this paper.

[9] It is not a valid objection to this statement to say that it is not true * * * according to the atomic theory. Because in the first place the atomic theory hardly carries one so far, and in the second place the atomic theory is, after all, only a group of ideas, and as such it can not properly be allowed to determine every tentative idea that one is to entertain.

[10] The postulate of indeterminism is put forth in a remarkable paper by M. J. Boussinesq, entitled "Conciliation du Véritable Déterminisme Mechanique avec l'Existence de la Vie et de la Liberté Morale," Paris, 1878.

M. Boussinesq's point of view is, however, essentially different from the idea which is here set forth. "Scientists are in agreement," says M. Boussinesq, "that physical and chemical laws are reducible in the last analysis to different equations," and, according to M. Boussinesq, indeterminism is linked with the behavior of differential equations near and at their singular points. This is certainly a very important idea, but the idea here set forth is that physical laws (differential equations) relate always to permanencies or quasi permanencies, and that no physical law exists (no differential equation has any meaning) in a turbulent system unless such a system presents what an Irishman might call momentary permanencies and what we, with more elegance, call quasi permanancies.

M. Boussinesq's indeterminism comes from singularities in action, as implicitly contained in a differential equation, whereas the indeterminism here referred to comes from a break, as it were, in initial or boundary conditions and the complete failure in application of any differential equation (except, of course, such differential equations as express the application of the principle of probability) until the system again comes to complete or quasi equilibrium. Thus the curve which represents the expansion of a gas on the $p\ v$ diagram presents an actual gap, the curve does not exist, when the gas passes through a turbulent condition.

What is stated above as to the distinction between the Boussinesq indeterminism and the indeterminism which is discussed in this paper, namely, that in one case we have a valid differential equation which has singularities and in the other case a break in bounding or initial conditions and an entire failure in application of any differential equation whatever, does not apply, of course, to any purely mechanical system but only to chemical systems.

instability. Indeed, an impetuous process seems always to be the collapse of an unstable state. Let us consider, therefore, two ideal cases where the condition of instability is assumed to be completely established at the start.

(*a*) Imagine a warm layer of air near the ground overlaid with cold air. Such a condition of the atmosphere is unstable, and any disturbance, however minute, may conceivably start a general collapse. Thus a grasshopper in Idaho might conceivably initiate a storm movement which would sweep across the continent and destroy New York City, or a fly in Arizona might initiate a storm movement which would sweep out harmlessly into the Gulf of Mexico. These results are different surely, and the grasshopper and the fly may be of entirely unheard-of varieties, more minute and insignificant than anything assignable. Infinitesimal differences in the earlier stages of an impetuous process may, therefore, lead to finite differences in the final trend of the process.

(*b*) Consider a smooth spherical ball traveling through still air. There certainly is no more reason to expect the ball to jump to the right than to the left. Therefore we may conclude that it will not jump either way. Similarly, a sharp-pointed stick stands in a perfectly vertical position in a perfectly quiet room, and there is no more reason to expect the stick to fall one way than another; therefore the stick will not fall at all. Everyone appreciates the fallacy of this argument as applied to the stick, and the moving ball does, in fact, jump sidewise.

To understand the behavior of the ball, let us think of the ball as standing still and of the air as blowing past it in a steady stream. The air streams past the ball and slides over a body of still air behind the ball; the surface which separates the moving air and still air is called a vortex sheet, and a vortex sheet is unstable. Any cause, however minute, is sufficient to start an eddy or whirl, and once started such an eddy or whirl develops more and more. Such an eddy or whirl means that the air streaming past one side of the ball is thrown inward or outward, and the reaction on the ball pushes the ball sidewise. This effect can be shown by dropping a marble in a deep jar of water. Instead of moving straight downward the marble follows an erratic zigzag path. This effect is familiar to everyone in the sidewise quivering of a stick in a stream of water; and the hissing of a jet of steam is due to the rapid fluttering of the boundary between steam jet and air because of the formation of innumerable eddies.

Whenever the postulate of erratic action is set forth, and the probable departure of a natural phenonenon from the most carefully considered prediction is urged as in the nature of things inevitable, we meet objections from two classes of men, namely, the average man who thinks frankly in terms of human values (the gardener who is not concerned with individual drops of rain) and the classicist in science who idealizes nature in one-to-one correspondences. Surely the classicist says, "if we knew all" the data we could make an unqualified prediction in any case. But, ignoring the hopelessly unscientific attitude of mind of one who can postulate infinite knowledge, let it be understood that to speak of data in physics is to speak of a very narrow and limited kind of thing, for data are conceivable only where measurements can be made or where we have, contrary to Bacon's exhortation, accepted a dream of fancy for a model of the world.

In that branch of mathematical physics which is called statistical mechanics and which includes the atomic theory, we speak of the complection of a system when we wish to refer to the positions and velocities of all the elements or particles of the system. Let us use this word in the statement of the postulate of indeterminism. *The complection of the world to-morrow is not determinate—that is to say, it does not grow out of the complection of the world to-day as a single-valued determinate thing.* This is a postulate which, as it seems, must be accepted as a working hypothesis in the "extra-equilibrium" world, the world of actual happenings, where things never do stand still but go forward by fits and starts impetuously and beyond all control.

The conception of a physical system as an atomic aggregate and reason for steadiness of behavior.

Let us consider a body of gas in a closed vessel. According to the atomic theory such a gas is an aggregate of a vast number of minute things and conditions, no one of which ever exercises a dominant influence upon the behavior of the system. Therefore, according to the principles of probability, the body of gas should present a remarkable steadiness of behavior and this steadiness of behavior should be more and more nearly complete the greater the amount of gas and the longer the time over which the behavior is averaged.

But suppose a state of affairs could be brought about in which a single one of the minute elements or conditions could be made to play a preponderating rôle in the behavior of the gas like the above-mentioned Idaho grasshopper or the Arizona fly. Then the gas would be extremely erratic in its behavior and the kinetic theory of such a gas would have to be something more than a straightforward development of the simple principle of probability to be of any great service. We would be interested in peculiar individual tricks of such a gas, and it is conceivable that these tricks might be infinite in variety. Mere averages, even mere averages qualified by probable departures, would be of little significance. A particular trick of the gas might be dependent upon the sudden dominance of one peculiar element or condition, and this particular trick might only occur once in a thousand years. Once in a thousand years, and we might be concerned with the behavior of the gas tomorrow. The only help in this case would be to study individual tricks with great care and patience and thus be able to recognize a particular trick in its incipiency and anticipate more or less accurately its future details of development. Classification studies of the most exhaustive sort, the recognition of certain type tricks and the correlation by probability methods of the details of development and extent of departures of an individual from normal or type should be made.

Imagine the gas, for example, to be slowly changing through a long series of equilibrium conditions, and imagine each of these equilibrium conditions to be in danger of breaking, as it were. Thus the containing vessel might be imagined to change its shape and temperature in a most complicated manner, growing thin at certain places and in danger of rupture and the gas might stream from one portion of the container to another and develop unstable states of motion which might break as a vortex sheet is known to break. This highly fictitious example is given to lead up to a fairly adequate statement of a very important fact as follows: *Any adequate statistical study of the behavior of a system which depends upon highly heterogeneous erratic elements must use exhaustive classification studies.* To be content with averages and departures derived from inadequately classified data would in such a case be as ineffective as to ignore the existence of species in the study of living forms.

Meteorology.

Meteorology has for many years been, one might almost say, the only branch of physics concerned with actual happenings, and the statistical methods which have been used in the past have been too much of the kind that are applicable to a homogenous aggregate of erratic elements. Statistical meteorological studies have in most cases involved the leveling process of simple averaging, whereas the conditions would seem to require classification, classification ten thousand times more exhaustive than any hitherto made. Of course there is some interest attached to the average in meteorology because systematic differences and rhythmic changes which are extremely important are discovered in this way, but even such things would be more easily detected if the averaging process were based upon a much more exhaustive scheme of classification. In thinking of emigrating to Mesopotamia after the war, the writer has wished to know what the average weather conditions there might be for a lifetime or two, but as a resident of Boston, he is chiefly concerned with the variations of Boston's weather. Will the late frosts next spring deprive him of apples? Will winter's cold make him wish he were in Florida? And if he should be driven to Florida what weather welcome would he get there? It is certain that the most important phase of meteorology is to deal with particulars and not with averages, and its ultimate aim is weather control.

Saying very little, therefore, of the need of researches of the classical kind in meteorology, for everyone recognizes this need, let us point out what seems to be most urgently needed in the most difficult phases of the subject and we make the statement brief in the hope that it will be interpreted with the help of what we have said concerning the new point of view that is developing among physicists.

Three fairly distinct objects are to be attained in the analysis of weather observations, namely:

(*a*) The determination of systematic variations in time and place. This object has long been recognized by meteorologists.

(*b*) The elaborate classification of individual storm movements with respect to a great number of measurable or specifiable characteristics, and the establishment of statistical coefficients of correlation between the characteristics of a given type of storm on successive days so that weather predictions can be made and qualified, as they should be, by probable departures. This object has, of course, been recognized by meteorologists but we believe that classification studies should be very greatly extended.[11] Effective schemes of classification can only be developed under the stimulus of intensive study of actual weather conditions (weather maps, let us say). This sort of study might properly engage the whole time of a large staff of men, and probably the observational work and instrumental equipment of the Weather Bureau would have to be altered in response to the clearly conceived demands for new kinds of data.

(*c*) The intensive study of weather conditions should lead to a clear recognition of critical conditions in a given storm movement (conditions of static or dynamic instability) and make it possible to devise means for controlling the storm movement by the suitable expenditure of very moderate amounts of energy at the critical time and place. Anyone who has seen an old-fashioned prairie fire brought under control by carefully considered backfiring, and who recognizes the meanings of static and dynamic instability in their influence on a complex physical system like the atmosphere, will accept this idea of weather control as a legitimate conception, to say the least. Whether it can ever be actually realized, however, is another thing; but it seems well worth the attention of the meteorologist. Although every atmospheric movement may, perhaps, be properly thought of as the collapse of an unstable state, it is probable that such collapse is already well under way in the earliest stages [12] of every movement so that extremely critical states may never develop. Therefore the energy required to control a storm movement might always be considerable in amount from the human point of view, although extremely small as compared with the total energy of the storm movement itself.

[11] Some of the more recent classification studies are as follows: Bowie, E. H., & Weightman, R. H.: Types of Storms of the United States and their Average Movements, M. W. R. Suppl. 1, 1914; Types of Anticyclones of the United States and their Average Movements, M. W. R. Suppl. 4, 1917.
Henry, A. J., Bowie, E. H., Cox, H. J., & Frankenfield, H. C.: Weather Forecasting in the United States, W. B. Pub. No. 583, 1916.

[12] The discussion of simple sweeps and of steady sweeps on pages 154-155 of Franklin and MacNutt's General Physics will help to make this clear.

DYNAMIC HEATING OF AIR AS A CAUSE OF HOT VOLCANIC BLASTS.

By George N. Cole, M. E., Associate, American Society of Civil Engineers.

Probably there is no field so virgin or inviting for scientific marshaling as that part of the meteorological domain which has to do with atmospheric phenomena caused by, and following, volcanic eruption. Its ramifications reach from the vapor condensation and electrical effects of the storm to the dynamic record of the destruction of things, animate and inanimate, that fall before it. At the eruption of Mont Pelé 30,000 human beings were killed in an instant under most appalling and marvelous circumstances, yet not a single autopsy was performed and no published account can be found that assigns a sure explanation of the cause of death.

In a previous paper [1] the writer has quoted at length eminent authorities who set for themselves the question, "What causes the deaths?", and all give practically the same answer, "The hot blast, bearing sand and steam from the volcano". This is corroborated by the learned Viennese geologist, Prof. E. Suess, and by B. Koto,[2] of Japan, who refer to the "hot vapors and steam cloud of Mont Pelé."

It will not be the function of this paper to inquire into the ordinary smoke, vapor, and electrical effects of the eruption. They are probably of the usual nature of storm phenomena, greatly intensified by the magnitude of the action, which involves great differences in temperature, with unusual volumes of water and volcanic matter. Our task will be an inquiry into those blasts which, with swift and stifling stroke, rend, burst, blister, ignite, and upheave all that oppose them till their fury is dissipated by distance and their ardor cooled by mixture.

Volcanoes are not laboratories. They can neither be selected in advance with even approximate certainty, nor can safe stations for apparatus be chosen. After the experiment, physical and biological changes of enormous magnitude must be read in terms of analogy from our experience.

Just after the Martinique disaster it was related to the writer that bodies had been found apparently unharmed and untouched except for blisters and burns and that these blisters were under clothing, at times as frail as lace, that showed no trace of fire or scorch, nor were there contiguous evidences of fire. These people had

[1] Scientific American Supplement, May 25, 1918, 85: 334-336.
[2] Tokio Imp. Univ., Coll. of Sc. Jour., 38, 1916-17, art. 3. B. Koto, p. 71

been killed in some mysterious manner, just as the people of Pompeii and Herculaneum had been killed, stopped on the instant. The cause of death was unfathomed in the recent case, as in the earlier. We believe it was the adiabatic compression of the enveloping air, with its consequent rise in temperature, that stifled and killed, in almost a twinkling, the victims of Mont Pelé and Vesuvius, of Taal, and Sakura-Jima. The problem is of vital human interest.

Such heating by compression was first advanced by the writer shortly after the Martinique disaster as the explanation of the death and blisters beneath untouched lace before alluded to, but it has been the desultory work of years to assure oneself of the originality and worth of the conception and to accumulate in a small way the analogies from authentic sources and broadcast experience which would insure its acceptance.

Let us consider, first, the physiological and structural effects of the hot blasts; second, from these let us stipulate what conditions of pressure, winds, and temperatures would be necessary to produce such effects; and third, let us compare such conditions with those which occur on a smaller scale in explosions of known intensity.

The physiological, or rather pathological, effects of the hot blasts seem to be both those resulting from rise in temperature and from the rise and fall of pressure as an explosive wave passes with greater or less rapidity. Observers have reported cases of the destruction of materials varying from practical annihilation to the case of lace and fine cloths untouched, over bodies blistered and killed. Trees are cited,[3] denuded of bark, with their fiber cut and shredded as by a sand blast. This is probably the manifestation of some such action as that which pops corn or puffs rice when the pressure is removed after heating and compressing the included juices or moisture. As to heat actions on man and brute, they are reported and photographed in great quantity and variety.

Mr. George Kennan in his Tragedy of Pelée reports quite extensively, among other interesting data, the interview with one, Caparis,[4] who was a negro town character at St. Pierre incarcerated for some minor offense. For attempting to escape the day before the disaster he was put into a deep dungeon for safekeeping and punishment. He was the only being of some 30,000 in St. Pierre who survived. Some persons doubt the existence of this negro, but my friend Walter C. Harris, with Louis Siebold, both of the New York World, state that while they did not see the man—they left in an hour and a half after arrival to escape the second eruption—they were given a photograph of him, of which I have a copy; and the story of him was so circumstantially told to them by different natives as to be true beyond question, and has recently been verbally confirmed to me by Mr. Lyder, who was a member of the Barbados Government relief expedition.

This man Caparis, Mr. Kennan tells us, had been burnt so deep that blood oozed from his wounds, and yet his hair was untouched, as was also the shirt covering the burns on his back. Caparis told him that he heard no explosion and smelled no odor of sulphur. He was in an underground cell with a door grated in the upper part and the air and dust came through and burned him. He heard no noise, saw no fire, and smelled nothing except what he thought was his own body burning. The water in his cell did not get hot, or at least it was not hot when he first took a drink, after the catastrophe.

[3] Dean C. Worcester, Nat. Geogr. Mag., Apr., 1912, Taal Volcano, p. 345.
[4] Tragedy of Pelée, George Kennan, 1902, p. 74, and following.

In the Philosophical Transactions of the Royal Society of London (vol. 200 A, 1903) Drs. T. Anderson and J. S. Fleet in their article "On the eruptions of the Soufrière and on a visit to Montagne Pelée in 1902," pages 353–553 and plates, give much valuable information and data. This supports the theory of the dynamic heat of compression, although it did not occur to them, and they cling to the older theory of black cloud, hot sand, and steam.

Their observations and statement as to the black cloud are the most minute we find, and are quite interesting. The cause of this black cloud, also alluded to by others, is not entirely clear to the writer, but may probably result from the formation of the enormous quantities of dust made by the solidification or condensation of the liquid and gaseous material which exploded violently on the release of pressure when ejected from the crater. It may also be that the high density of the atmosphere as it comes under compression would so vary its refraction, especially with its undoubtedly disturbed surface, as to cause it to become nontransparent and dark. Another factor in the production of the black cloud must be the dust blown up from the surface by the tremendous wind.

Their report notes in one instance sufficient heat in ashes to scorch a negro's skin but not for two hatfuls of the same hot ashes to singe his hair. Their records of pages 396–398 strongly illustrate experiences on the outskirts of the danger zone of an eruption, especially their reference (p. 398) to the Fancy estate: "Those who escaped were badly burned mostly on the hands, the feet, and the face, but others also on parts protected by clothes, though their clothing was *not scorched* or *ignited*. The dust in the cloud was not red hot and consequently did not set anything on fire, the burns being apparently due to *steam and other gases*." The italics are our own.

The other extreme of burning observed after such volcanic blasts is that in which torsos of bodies burned beyond recognition with the cement of sand on them after burning are found in situations where all wood and inflammable material was likewise ignited and consumed. One case of disrupted bowels is cited in the Century Magazine for September, 1902, which may have been the result of flatulence and a sudden reduction of pressure after the pressure blast.

Destruction of material objects shows the action of a tremendous blast from the direction of the crater. Ground plans have been plotted for numerous eruptions and they show irregular, but, in a measure, concentric fields. Photographs taken of volcanically destroyed localities also show these nicely graded zones of destruction from that of utter havoc nearer the crater, to those exterior zones where whole villages are still partly standing with walls destroyed across the line of march of the pressure front, but with walls which coincided with the direction of approach of the pressure preserved. Dr. E. O. Hovey in his remarkable photographs of St. Pierre, Martinique (Bull. Amer. Museum of Natural Hist., Vol. XVI, plates), states in description of Plate XLV: "Ruins of St. Pierre from the south—the north and south walls have been injured by the eruption less than the east and west walls." It will be noted that the crater was situated to the north of these walls. He also exhibits photographs showing trees all thrown down in a direction away from the crater.

Observations leave no doubt that there is a tremendous hot blast with a great wave of pressure emanating from the crater generating a terrific compression with its attendant high adiabatic temperature since there is little

time for dissipation of this heat. This compression of gases at the crater is accomplished by three actions:

First. The magma of the volcano approaching the outlet as a liquid, due possibly to some modification of a deep internal regelation, under heavy pressure and with intense heat is probably in the condition of the water in a boiler exploding under such intense pressure and its attendant temperature that the heat contained in the water causes the whole of the water to flash into vapor. By analogy we may possibly conceive of the ejecta of the volcano being entirely vaporized on its release to external pressure, later, on condensation, to become the sand and grit that covers the landscape. The mechanical extrusion of this vapor in itself makes the first wedge to crush the air into compression before it.

Second. The heat of this extruded matter, even after the expansion of emission, in its action on the surrounding air will cause it to expand, as the air in a back draft at a building fire, so that the expansion of the air itself will cause the air retaining it to be thrown into compression.

Third. Some of the extruded gases may be inflammable, and by their conflagration cause further heat and expansion, which will bring to bear further action compressing the outside counteracting atmosphere.

These three causes combine to give a drive and pressure to the retaining atmosphere beyond anything obtaining in other atmospheric disturbances both as to velocity and temperature.

This gives rise to destruction as complete in the outer zones of action as if done by a tornado. The velocity of the wind near the crater is incalculable, but must be of the order of more than 100 meters per second. The temperature of the gases, likewise incalculable at the crater, must range from 500° or 1,000° C., or beyond, to 200° or 300° C., where things are charred, and to over 60° C., where people were burned without their clothing having been affected. Furthermore, such temperatures must have been maintained for a time sufficient for the surfaces to get warmed to a temperature sufficient to produce the observed burns. It is a matter of common experience that only a second or two is enough for hot air to produce a burn and less than a second for steam to scald, while it may take some considerable time for a third-degree burn or worse.

Macleod, in his "Burns and their treatment," of the Oxford War Primers, gives us the discussion from which the following notes are taken: A burn is caused by a dry heat of about 140° F. (60° C.) and above; a scald by 125° F. (52° C.) and over. The degree of severity is dependent on—temperature, area exposed, and duration of exposure. The area affected is more serious than the depth of the burn. Six degrees of burns are recognized: (1) From a temperature of 140° F., redness, slight œdema (effusion of serous fluid), smarting, and tenderness; (2) from 160°-210° F., marked blisters, protoplasm coagulated; (3) above 210° F., hard crust or scab is formed; (4) longer exposure to high temperatures, disintegration of skin tissues; (5) still longer cooking, with disintegration of muscles; (6) higher temperatures, carbonization. Burns involving more than one-third of the surface of the body are serious, if not fatal, and those involving one-half are almost invariably fatal. The more intense degrees of severity of burns would naturally take some time for their accomplishment and might be a measure of the duration as well as intensity of the heat involved. Mucous membranes are also seriously affected by the inhalation of the hot vapors. As the temperatures increase, hair and eyelids, ears and nostrils, will be affected. Thus from the observed effects we have a rough basis for judging the temperatures which occurred.

To estimate the increase of pressure in the compressional wave, we can use (1) the strength of the blast produced; or (2) we can estimate how much increase or decrease in pressure would produce the collapse or explosion of buildings, trees or people; or (3) if we assume the high temperature to be wholly a result of adiabatic compression, we can use the estimated temperatures as a rough basis. Let us consider each. In an explosive wave it is probable that the pressure front in the destructive zone moves at a velocity greater than that of sound, or at a speed perhaps of 400 meters or more per second, varying with the actuating force, and having a destructive force inversely proportional to the distance. Thus the wind speed, no matter what the gradient, could attain a velocity of 400 meters per second were it not for viscosity and friction. The explosive effect of tornadoes seems small compared with that of the passing explosive wave with its hot blast, until its force is about dissipated. Barograph traces made at a slight distance from tornadoes have shown pressure reductions as great as 10 per cent, and it is presumed that in the tornado itself the reduction may be much greater. A release in pressure so great as this is capable of exploding buildings and probably also is able to explode bark on trees and to kill people, although it has none of the marked heat effects of the air compression. An explosive wave, however, is a study of much higher compression and its reduced pressures follow necessarily from the fact that there is the preceding compressional wave by virtue of the air from behind being thrust into that in front. The compressions we are considering are those involving some little length of time and magnitude of expression, before the action has so expanded as to be a mere wave motion. Our thesis covers the part of the field of action outside of total destruction, where heat effects are of such modified intensity and duration as to leave observable effects on material and living objects.

On man and brute in this zone the sudden rise in pressure, aside from its heat effects, must be indescribably worse on the eardrums than going through an air lock in caisson work. Lung and heart action must be stifled since the ordinary maximum difference between the inside and outside of the lung wall, on strong stopped expiration, is from 60 to 100 mm. of mercury, or about one-tenth of an atmosphere. Then, depending on the length of application, in case the subject can breathe at all, is the absorption of air into the blood, with the consequent liability to "bends" on release. On the relaxation of this pressure, with its consequent relative vacuum, all the contained air in structure of plant or body becomes a bursting charge if not sufficiently secured. In animals, even if there is no explosive effect, the nitrogen will form bubbles in the blood if the pressure has been sufficiently prolonged, and in this way clog the circulation and cause death.

The pressure necessary to cause the different degrees of heat, if we assume (as is reasonable with such sudden compression) that the heating is adiabatic, or without loss of heat during compression, may be determined from the well-known gas formulas.

The relation between temperature, pressure, and volume of air at the beginning and ending of adiabatic com-

pression (or expansion) can be deduced from Charles' and Boyles' Law as follows:[5]

According to these laws

$$P_1 V_1 = P V \frac{T_1}{T} \text{ - - - - - - - - - - - - - - - - (1)}$$

whence

$$\frac{P_1}{P} = \frac{V T_1}{V_1 T} \text{ - - - - - - - - - - - - - - - - (2)}$$

For adiabatic compression

$$\frac{P}{P_1} = \left(\frac{V_1}{V}\right)^{n} \text{ - - - - - - - - - - - - - - - - (3)}$$

or

$$\frac{P_1}{P} = \left(\frac{V}{V_1}\right) \text{ - - - - - - - - - - - - - - - - (4)}$$

In which n is the exponent of adiabatic compression, 1.406, and is the ratio of the specific heats of air at constant pressure and constant volume.

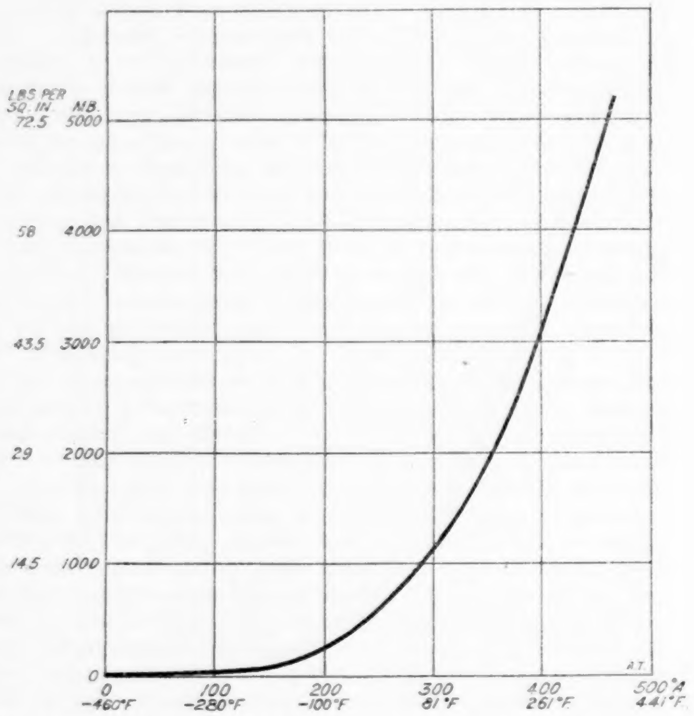


FIG. 1.—Temperature changes under adiabatic compression. Adapted from Thurston's tables. Correction: Change 81° F., 261° F., and 441° F. to 80° F., 260° F., and 440° F.

Combining (2) and (4)

$$\left(\frac{V}{V_1}\right)^{n} = \frac{V T_1}{V_1 T}$$

whence

$$\left(\frac{V}{V_1}\right)^{n-1} = \frac{T_1}{T} \text{ - - - - - - - - - - - - - - - - (5)}$$

and

$$\frac{V}{V_1} = \left(\frac{T_1}{T}\right)^{\frac{1}{n-1}}$$

or

$$\frac{V_1}{V} = \left(\frac{T}{T_1}\right)^{\frac{1}{n-1}} \text{ - - - - - - - - - - - - - - - - (6)}$$

[5] From Simons', Compressed Air, p. 26.

from equation (3)

$$\frac{V_1}{V} = \left(\frac{P}{P_1}\right)^{\frac{1}{n}} \text{ - - - - - - - - - - - - - - - - (7)}$$

or

$$\frac{V}{V_1} = \left(\frac{P_1}{P}\right)^{\frac{1}{n}}$$

whence

$$\left(\frac{V}{V_1}\right)^{n-1} = \left(\frac{P_1}{P}\right)^{\frac{n-1}{n}}$$

and combining with equation (5)

$$\frac{T_1}{T} = \left(\frac{P_1}{P}\right)^{\frac{n-1}{n}} = \left(\frac{V}{V_1}\right)^{n-1}$$

Based on these equations, a general summary of the relations between pressure and temperature in adiabatic pressure changes is shown in Table 1 and Figure 1.

TABLE 1.—*Temperatures in adiabatic compression or expansion.*

[Adapted from tables by R. H. Thurston, 1874.]

In these tables the temperatures are slightly inaccurate, absolute zero being given as −274° C. and −461.2° F., instead of −273.1° C. and −459.6° F.

Pressure.			Temperature.		
Pounds per square inch.		Millibars.	°F.	°C.	°A.
Absolute.	Gauge.				
5	−10	345	−80	−62	212
10	− 5	690	5	−15	259
15	0	1,035	63	17	291
20	5	1,380	109	43	317
25	10	1,725	147	65	339
30	15	2,070	180	82	356
40	25	2,760	236	114	387
50	35	3,450	282	139	413
75	60	5,175	375	190	464
100	85	6,500	447	231	505
500	485	32,500	988	531	805
1,000	985	65,000	1,258	681	955

This table shows at what relatively low pressures, added to the atmospheric pressure, severe temperatures are reached. To make this more closely applicable to the conditions which probably prevailed at St. Pierre, let us assume that the original temperature was about 80° F. and the original pressure somewhat below the mean for sea-level, say, 1,000 millibars (equivalent to the pressure shown by a barometer reading, 750.1 mm. or 29.53 inches).

Table 2 shows what pressures would be necessary to produce the temperatures required for burns of the first degree, of the second and third degrees, and of the sixth.

TABLE 2.—*Temperatures in adiabatic compression or expansion.*

[Initial temperature, 27° C.; pressure, 1,000 mb.]

Pressure.			Temperature.		
Pounds per square inch.		Millibars.	° F.	° C.	° A.
Absolute.	Gauge.				
14.5	−0.5	1,000	81	27	300
21	6	1,430	140	60	333
31	26	2,120	212	100	373
70	55	4,800	392	200	473

In other words, if the observed burns were due to temperatures produced by the heat from adiabatic com-

pression, there must have been a pressure of about five atmospheres for the charring, a pressure of over two atmospheres for the severe burns, and a pressure of at least one and one-half atmospheres where there were superficial burns, provided that the pressures stated lasted for something like a second.

There are many examples of this adiabatic compression of air with its resulting heat, e. g., the heating of the old bicycle pump in the hand when in use is probably the most intimate; the fire-cylinder experiment of the physical laboratory where the piston of a closed cylinder is pushed down so far and so quickly that a bit of tinder in the compressed-air chamber bursts into flames; the Diesel motor which is actuated by the explosion of oil ignited upon being sprayed into air compressed adiabatically to a very high temperature. Each detonation of a high-explosive shell has about it the various zones of its own hot gases and the counteracting compressed hot air of a miniature eruption. So that with these and other examples it is a heat of which we have experienced various analogies and in its lighter stages is readily comprehensible. The heavier manifestations of this heat are more difficult to fathom. Mixed as they are with the equally terrific results of air motion there is good reason for there having been no previous differentiation of their coincident effects.

The observed phenomena, then, show that the hot volcanic blast is characterized by a wind velocity exceeding 100 meters per second, by temperatures from above 200° C. down to 60° C. within a zone of several miles, and by a pressure wave which probably ranges from a pressure of one and one-half atmospheres to one-half an atmosphere, and which may have a pressure of more than five atmospheres.

The cause of such a blast is obviously a tremendous explosion, however undeterminate, exerted upward, but conforming, in a measure, to the effective axis of the outlet, the whole process being liable to distortion, due to the barricading of crater walls and mushrooming, due to diverse air strata encountered. This explosion throws solid and liquid lava and hot gases in all directions. It sends out at a tremendous velocity a great compressional wave with an approximately spherical front. Such explosions can throw rocks more than 30 miles, and the liquid lava makes almost unbelievable quantities of volcanic dust. The hot gases are forced to not great distances. The explosive surge has an unknown change of pressure. It is obvious, however, that an explosion of such intensity as to make appreciable pressure waves encircle the earth, as at the time of the Krakatoa eruption, must produce a tremendous initial wave of compression and expansion, the initial compression being of some duration, depending on the suddenness and persistence of the source and the following rarefaction conforming to it in magnitude.

The amount of pressure will probably never be determined. In the great Krakatoa explosion an island disappeared and a boulder was hurled over 30 miles, ascending 30 miles in its flight and surpassing our usual 16-inch gun to an incalculable degree. Since the missile was fired by a flare or explosion rather than within a rifled barrel, the intensity must have been incalculable times that of a great gun.

Let us turn to the causes for the various grades of destruction. Those near the crater are due to the explosive action and heat of the gases as they emerge. These gases hurl and burst the material of the mountain so as to obliterate or cover it in an indescribable manner. But these gases and missiles do not of themselves necessarily range far in their travels. The wide damage seems to be done by the action of the surrounding atmosphere, through which moves the compressional action produced by the explosion.

Quoting from the second volume of Marshall's Explosives (p. 621), recently issued,[7] we find that—

> Experiments have been carried out at various times and places to ascertain the distances at which explosives will produce a specific effect according to the quantity of explosive used. In the French experiments different quantities of the various explosives were exploded in the open, and at various distances a number of little screens were erected, so arranged that the same degree of force would cause each of them to fall back. It was thus possible to ascertain the distances at which the same effects were produced. The most simple theory would lead one to expect that the distance would be proportional to the square root of the weight of the charge. These experiments, which were carried out with quantities of 0.1 to 100 kg. of melinite, 150 kg. of chedite, and 300 kg. of gunpowder were in agreement with this theory. They were confirmed by trial in which small huts with glass windows were exposed to the effects of the explosives at various distances.
>
> This rule is expressed by the equation $d=K\sqrt{c}$, where d is the distance, c is the weight of the explosive, and K a constant depending on the nature of the explosive and the sort of damage considered.
>
> For high explosives causing the breaking of window panes and slightly injuring the frames and wooden walls K=10, about, the distance being measured in meters and the charges in kilograms. L'Heure also determined the velocity with which the impulse of explosives is transmitted through the air. Near the seat of the explosion the velocity is much greater than the normal velocity of sound, but it falls off rapidly and at about the distance at which window panes are no longer broken the velocity is the same as that of sound. The more brisant [sharper] the explosion the greater is the initial velocity of the impulse. Increase of the quantity of the explosive does not seem to increase the initial velocity but it causes the rate of diminution to be less.
>
> For small quantities of explosive the distances of equal effect are nearly proportional to the cube root of the weight of the explosive and for very large quantities the variation of the distance is more nearly proportional to the increase of the weight.
>
> The gases formed in powder explosions are projected to comparatively small distances. When 7,000 pounds of gunpowder exploded at Faversham, England, and the conditions were peculiarly favorable to lateral projection, the scorching effect did not extend over 50 yards, whereas serious structural damage was done at 283 yards and windows were broken at a mile.

Could not some computations be made to show the amounts of pressure change accompanying explosions of varying intensities, and to show the damping effects of the atmosphere on such compression waves? From such it might be possible to compute the initial intensity of any explosion from the distance to which the destructive effect reached.

In the volcanic eruption the question is, Do the hot crater gases actually sweep down the mountain as a withering blast effective for miles around? If not, the hot blast must be the result of compression on the front of the explosive wave. The fact of pressure disruption of trees, buildings, and even of men, and the reported compression of the air in Caparis's dungeon, and the burns under clothing indicate a pressure wave of sufficient magnitude to produce the observed heating and wind effects. A blast of hot gas would, however, also be accompanied by a pressure wave, though not so intense as the explosion wave. Since, however, in many devastated locations no gases were smelt so far as known, it seems reasonable to explain the hot blast as the result of the passage of a tremendous compressional wave traveling at a speed exceeding the velocity of sound (which is about 335 meters per second). Such a wave would kill by compression and rarefaction as well as by burning. The duration of the high pressure at any

[7] Explosives: Arthur Marshall, P. Blackiston's Son & Co., 1917. 2 vols.

spot may be as much as a half or even a whole second or longer, depending, upon the persistence of the source.

To prove this point, further observations of the intensity and duration of the explosive wave are necessary. The destructive forces in play make observations impossible. Instruments set to register and yet resist demolition, in case the time and place can be foretold are the best that can be hoped for. These instruments should be designed to register pressure, duration, heat, and if possible gather some of the atmosphere. Much ingenuity will be required in the design and making so that they will be indestructible, self-contained and yet give access for calibration and for reading and determination. As an initial suggestion, and for want of better, it is believed that pressure can best be determined by an aneroid cell of heavy metal with copper points within it, attached to either plate, arranged for indentation. Possibly the cell can be screwed together by threads in its cylindrical part, thus allowing proper setting, testing, and reading. The indenting plug might be widely conical with a spiral ridge. There could be used also containers set with a spring plug that would allow entrance of air or gas at given pressures but stopped for egress. These if exhausted when set would keep air samples and might retain their maximum pressure.

Duration of pressure might be obtained by a timing mechanism within a strong capsule which would be released for motion while the pressure is acting on the plates of the container.

Temperatures and heat would probably be best registered by their effects on exposed objects since the action may be too speedy for other registration. Thermopiles might be arranged to register their throw or to indent their difference of expansion.

Records, after all, will generally be obtained by visits, as soon as may be, to fields of action, and by the preservation or the measurements and description or photographs of specimens, also by attempting through physical and chemical processes to duplicate observed changes. A special set of apparatus that will register results in the midst of great pressure disturbance will need to be designed, in case it is thought it can be advantageously placed.

How can safety be achieved? With a wave traveling at such a termendous speed there is little chance to seek safety; but presuming it is possible, all of three things are necessary in a "volcano cellar"—stability, heat insulation, and pressure insulation. If one is inside the danger zone none of the above can be overlooked. On the outskirts of devastation, cellars, dungeons, caves, wells, or cisterns may help some, but it will all be a matter of the severity of the pressure at that particular place. If the pressure comes on it will heat the air of a cavern a hundred feet underground. For protection is simply a case of having heat absorbed by surrounding objects or by sprayed water faster than it can be generated by the compression.

A form of protection could be secured by the firm placement of a steel chamber, such as is used about caisson contracts for the treatment of those taken with caisson disease or bends. Such an air lock securely placed, heat insulated, and with air-tight doors, would be a safe refuge, provided the strain on it was not too great in any one of the three essentials. Crusher gages such as are used in rifles could be operated in its shell.

No matter what prepared protection there might be, a previous, thorough wetting of the body might be a protection against burning from air in case it is hot only about a second. In some therapeutic treatments, the body covered with wet clothes is exposed to temperatures up to 200° C. If there are poisonous gases there would be little chance for escape without a gas mask as well.

The whole matter is in a formative stage. That heat of compression is the large fatal factor to man exposed to eruptive volcanoes seems most probable, for the explosions are probably great enough to produce a pressure wave capable of heating the air to 60° C. or more for miles from the source. That this compression ignited buildings and ships, crushed in the hatches of the steamship *Roraima*,[8] denuded trees and shredded their pulp, is almost as evident. Furthermore, nicely graded effects could not have been accomplished by the ravage of hot or flaming crater gases. What can be shown by close and immediate inspection will develop. Heaven grant a long wait unless it be another Katmai without casualty.

DISCUSSION.

Theoretically, temperatures exceeding 200° C. may accompany an explosive wave of volcanic intensity. The absolute temperature of a gas varies as the total kinetic energy of the gas, i. e., as mv^2 in which m is the total mass of the molecules, and v is their average velocity. This kinetic energy can be raised by increasing the mass in a given volume without changing the velocity or by increasing the velocity by adding heat or moving the gas forward at a velocity exceeding the average molecular velocity.

According to Watson's physics,* page 171, the average molecular velocities of a few gases at 0° C. are as follows:

	Meters per second.
Hydrogen	1,859
Nitrogen	492
Oxygen	465
Carbon dioxide	396

Since air is approximately four-fifths nitrogen and one-fifth oxygen, the weighted molecular velocity at 0° C. is about 485 m./s., or at 27° C. (300° A., 80° F.) about 510 m./s.

Suppose, as seems possible, an explosion actuating the air for one second pushes the immediately surrounding air forward at a velocity of 510 m./s. If the next zone of air did not move while this air in motion was driven into it, there would be at the end of one second a zone of air 510 meters thick in which the kinetic energy has been doubled because the mass of air in that zone has been doubled, the average molecular velocity remaining the same. (Relative to a stationary object the kinetic energy of a passing blast would be still greater.) The absolute temperature would, therefore, be doubled, i. e., 600° A. Such a temperature obviously would not be reached, for the air into which the explosive surge was driving would give way to some extent. If half of it got out of the way, the temperature would be 450° A., and if even 85 per cent were driven forward the temperature would still rise high enough to burn people.—*C. F. B.*

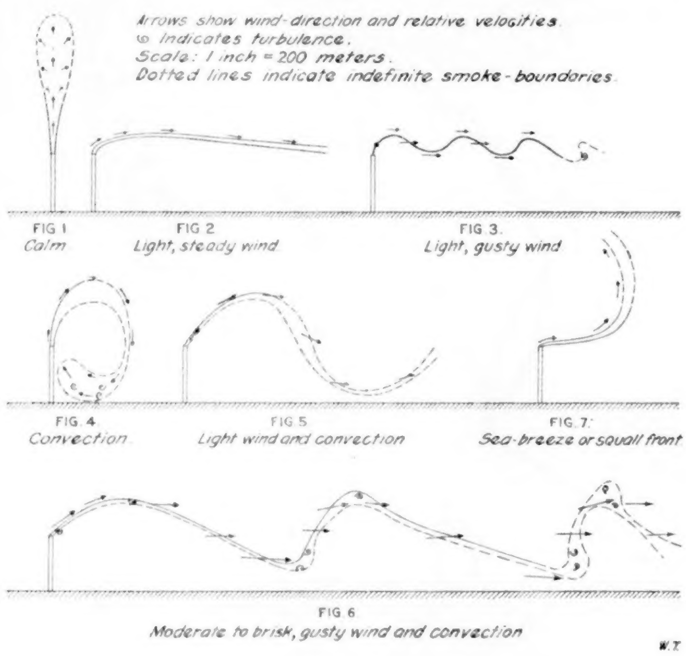
[8] Chief Engineer Scott, Eruption of Mount Pelée, Cosmopolitan, July, 1902, p. 250.
* W. Watson, A Textbook of Physics, London, 1900.

SMOKE AS AN INDICATOR OF GUSTINESS AND CONVECTION.

By P. W. ETKES, Met. Serv. S. C., and C. F. BROOKS, Meteorologist.

[Dated: Washington, D. C., Nov. 14, 1918.]

Observation of the form of the smoke line issuing from a tall stack will give the aviator considerable information concerning the flying conditions in the lower 100 meters of air. The form of the smoke line issuing from a tall stack is a function of gustiness, turbulence, convection, and gravity. Aside from the effect of the wind, heated smoke will rise rapidly and later the particles may settle to the ground. Wind blows the smoke from the top of the stack and usually determines the angle of ascent. Gustiness in the wind varies the angle of rise and makes apparent waves. Local up-and-down movements either from turbulence produced by the irregularities of the earth's surface, or from local heat convection will accentuate the wavelike form produced by gustiness. Turbulence will dissipate the smoke quickly. There seem to be six or



seven types of smoke form (see figs. 1–7). Let us consider each type, numbered according to the figures:

1. *Calm.*—In a calm, the smoke will issue vertically at an initial rate of two or more meters per second; but it will soon stop, as cooling, chiefly by the expansion of the heated gases and by mixture with the surrounding air, reduces the temperature of the smoke to that of the surrounding air, and allows the smoke particles to begin to fall.

2. *Light, steady wind.*—If there is a light, steady wind, the cooling by mixture goes on so rapidly that the smoke rises perhaps for less than a minute, and then very slowly falls. As may be observed often, the smoke will maintain itself in two proximate, parallel lines formed by the opposite, outward curls made when the smoke leaves the stack. At night, the smoke will travel miles and ultimately collect in a sheet marking the upper boundary of the nocturnal inversion, where the smoke particles in the undisturbed sheet fall but slowly through the dense air.

3. *Light, gusty wind.*—Figure 3 is theoretical, for gustiness is probably never found without vertical movement of the air. There are times, however, when vertical currents seem to be much less effective than horizontal changes in velocity in producing the observed smoke curve. When a gust blows across the top of the smokestack the smoke is blown off nearly horizontally and immediately begins to overtake the smoke which just left at a smaller velocity. In the lull which follows, the smoke may rise at an angle of 45 degrees and thus reach an elevation 20 or more meters above the smoke blown off in the gust. Another gust following sends the smoke off horizontally again. In this way, an apparent series of "waves" is formed, in which, however, there is no vertical motion except where the smoke issues from the stack. Because of relatively slow movement, the crests of these "waves" are slightly closer together than the troughs; and the more rapid movement of the troughs soon dissipates the smoke. As in the case of the steady wind, the smoke in this series of "waves" is slowly falling. The fall is relatively rapid if the density of the air is low and the air moist.

4. *Convection.*—On a clear day in summer when there is no progressive wind, there will be occasional light convectional breezes. The smoke may be caught in a local convectional circulation, rise, turn, and come down in a great curve even to the ground at the base of the smokestack. At College Station, Tex., the smoke from a 62-meter stack has been observed to descend at a rate of 2 meters per second. The condition illustrated in figure 4 was seen at noon one day early in September, 1918.

5. *Light wind and convection.*—As in the case of type 3, convection and a light wind without gustiness probably do not occur. Nevertheless, there are occasions when this type is to be observed in a nearly pure form. Here there is true wave motion, and the form of the curve is that which would result from combining the movements indicated in figures 2 and 4.

6. *Moderate to brisk, gusty wind and convection.*—Figure 6 illustrates the complexity of the smoke line as it is usually observed. Let us follow the development of this curve from that of a light steady wind. As convection on a clear day sets in shortly after sunrise, the lower air to a height of 50 or 100 meters may become disturbed within an hour and a half after sunrise, when the night temperature inversion is moderate, or within three hours when there is a strong inversion and relatively weak sunlight, as in autumn. The smoke sheet collected during the night loses its stratified character, becomes distributed throughout the air between the ground and the upper limit of convection, and slowly dissipates as convection brings in larger and larger volumes of fresh air. The smoke line itself as it issues from the stack and floats away assumes a wavy appearance when the upper limit of convection reaches that height, and so introduces vertical currents and makes the wind gusty. As convection goes still higher the downward components of the convectional circulation bring down greater wind velocities. So the apparent waves increase in wave length and in amplitude. A strong, somewhat downward current of air in a passing convectional cycle blows the smoke rapidly away and downward from the top of the stack. This smoke begins to overtake and run under the upward and more slowly moving smoke that went just before. Following this there is a lull in the wind and then another increase in wind velocity with an upward movement as the next cool gust forces the warm air in front of it to rise. The result is the formation of large "waves" in the smoke, waves having practically right angles at trough and crest, and having their steepest

faces toward the wind. Turbulence and the more rapid movement of both trough and crest than of the middle of the "wave" dissipates the smoke in two or three minutes. In windy, cloudy weather the form of the smoke is essentially the same, for the waves produced in the wind by the unevenness of the ground have vertical movements somewhat like those of local heat convection, though usually on a smaller scale.

7. *Sea breeze or squall front.*—On the front of a sea breeze, the smoke blows inland from the top of the smokestack, but is carried up and returned seaward aloft. This has been observed from Blue Hill, Mass., on several occasions. There is the same bow formation on the front of a thunder squall, though the turbulence is so much greater that the bow is not so long.

From these observations of smoke, it seems that in so far as smoke movements make air currents visible, smoke becomes a valuable indicator of the structure of the wind.

THE STRUCTURE OF GUSTS.[1]

By Major C. C. TURNER, R. A. F.

[Abstract.]

In a steady wind an airplane itself moves as if in a calm. Thus, if the wind is unsteady the number of gusts encountered in a given time will be the same whether there is a following or a head wind. And if, as anemometers indicate, gusts have no more abrupt onset than end, the effect of a gust from in front or of a lull from behind should be the same. Nevertheless, aviators say they can feel the difference between a head wind and a following one, and that they can climb fastest against the wind. Soaring birds apparently have the same experience. This would seem difficult to explain in any way other than that gusts begin more suddenly than they end. Apparently, we need more refined observations to show what the difference is.—*C. F. B.*

A VIRGINIA TORNADO.

By Prof. ALBERT W. GILES, University of Virginia.

[Dated: University, Va., Oct. 28, 1918.]

On October 29, 1917, a tornado occurred in the southern part of the State of Virginia that seems worthy of brief record. Gretna, a small village of some 200 inhabitants, situated in the north-central part of Pittsylvania County, 27 miles north of Danville, and on the main line of the Southern Railroad, was directly in the path of the disturbance and suffered severely. As a matter of fact, the destructive effects of the tornado were limited essentially to Gretna itself, its path being traceable but a short distance on either side of the town.

Tornadoes are very rare in Virginia. Greeley in his American Weather records less than five for the western part of the State between the years 1794 to 1881, and no published descriptions of this type of storm as occurring within the confines of the State are known to the writer.

In the study of the Gretna tornado no features new to tornadoes were discovered. It was simply a small storm of its class manifesting the usual phenomena. However, the date of its occurrence, very late in the autumn, is worthy of especial note as well as the lateness of the hour, 10:40 p. m.

[1] Aëron. Journ., London, 22: 285-6, 1918.

Its path from the south-southwest toward the north-northeast may be traced continuously for a distance of about 2 miles, closely paralleling the Southern Railroad. In no place examined was the width of this path greater than 600 feet and locally it was but 150 feet wide. The accompanying map, figure 1, displays the direction of its course through Gretna.

The first evidences of destruction were found about one-fourth of a mile south of Gretna along the left side of the main highway. Here one or two trees had been twisted off and two straw stacks had been blown over. Passing beyond these the tornado crossed the main high-

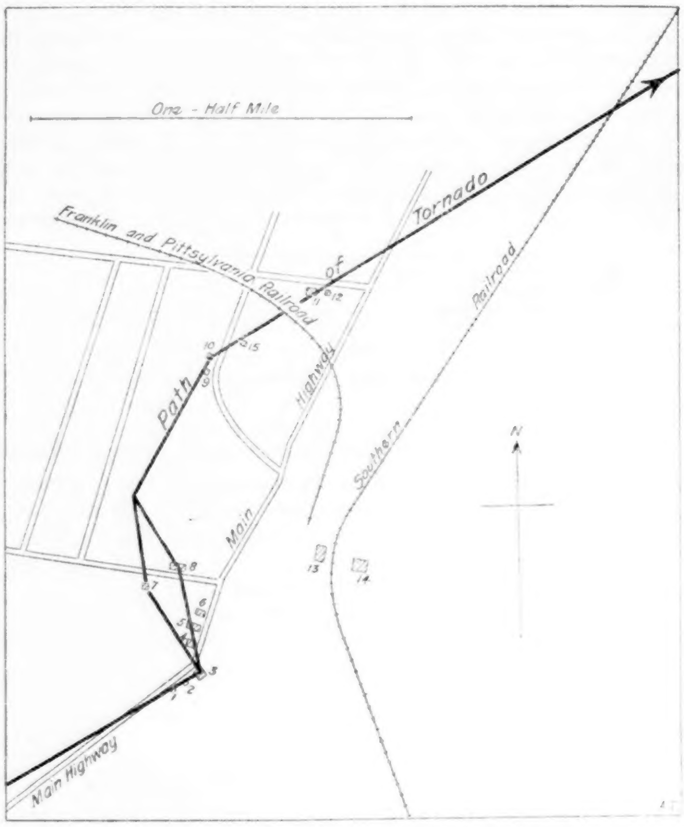


FIG. 1.—Sketch map of Gretna showing the path of the tornado through the village.
1. The Myers home.
2. The Easthan home.
3. Large tobacco warehouse destroyed.
4. Tobacco warehouse damaged.
5. Gretna Livery, Feed, and Sales stable.
6. Post office.
7. The Pickral home.
8. Powell's store.
9. The Eddie Bennett home.
10. The Dr. Powell's home.
11. The Christian Church.
12. The Adams home.
13. Southern Railroad station.
14. Virginia Hotel.
15. The J. E. Bennett home.

way and encountered the houses on the south side of the village. The first was a small frame structure (1, fig. 1) occupied by Mrs. Susie Myers. It was set back 3 or 4 feet and the back end rotated 8 feet from its normal position. Notwithstanding the unusual movements of her home Mrs. Myers preferred to remain in bed rather than to go out and face the storm. The next house (2, fig. 1), 100 feet north of the Myers home, was severely shaken but not damaged. The tornadic whirl apparently lifted over it only to descend with destructive violence on a large tobacco warehouse north-northwest 100 feet beyond. This building, 40 by 80 feet, substantially constructed of boards and three stories high, was totally destroyed (3, fig. 1).

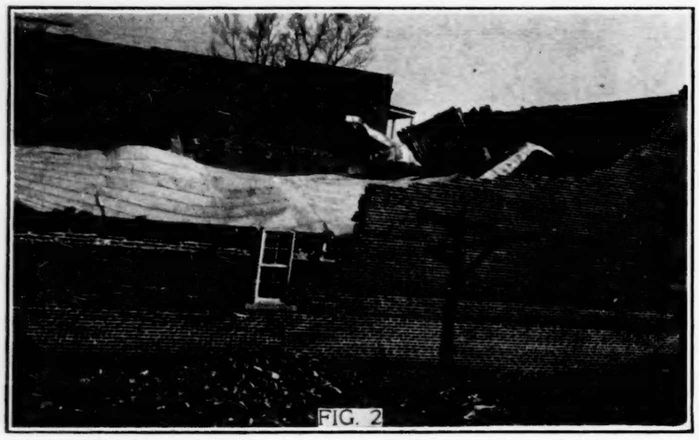


FIG. 2

FIG. 2.—The ruins of the Gretna Livery, Feed, and Sales Stable. The tornado was traveling toward the northwest here and just missed the post office, the brick building in the background. Looking northeast. (E. H. Stevens, photo.)


FIG. 3

FIG. 3.—Ruins of the Bennett home in the foreground, and the Powell home in the background. Looking northwest. (E. H. Stevens, photo.)


FIG. 6

FIG. 6.—The rear of the Adams home. Looking northwest. (E. H. Stevens, photo.)


FIG. 4

FIG. 4.—Front portion of the Bennett house, turned bottom upward and blown eastward, lodging against the shade tree at the street curbing. Looking west. (E. H. Stevens, photo.)


FIG. 5

FIG. 5.—The remains of the Christian Church. The greater part of this structure was distributed along the pathway of the tornado for the distance of one-half mile to the northeast. Looking north. (E. H. Stevens, photo.)

Immediately after hitting the warehouse the tornado changed its direction to the northwest, and crossing the main highway again, split into two minor whirls, judging from the destructive effects. The whirl that took the right-hand course damaged a large tobacco warehouse (4, fig. 1), warping and twisting it, and then completely removed the top and upper story of the new brick structure occupied by the Gretna Livery, Feed & Sales Co. (5, fig. 1 and fig. 2). The almost complete destruction of this newly built and modern brick building affords an indication of the enormous forces resident within a tornadic whirl. A wagon body was carried 300 feet from this building, and hacks standing in a shed at the rear that was unroofed were turned upside down. From this brick building the tornado jumped a low shed, and striking the store of R. B. Powell (8, fig. 1), completely demolished it. One-eighth mile northwest of the Powell store the two whirls, which had followed nearly parallel courses, appear to have joined. The destructive effects of the left-hand whirl were limited, for its pathway lay largely through open country. However, it twisted the top off a well, unroofed a house, and picked up a small outbuilding, which it placed roof downward on the opposite side of a fence. A small two-story dwelling (7, fig. 1) standing 500 feet southwest of the Gretna livery stable was also demolished by this whirl, and its débris strewn for one-fourth of a mile northwest.

The reunion of the two whirls did not decrease the potency of the tornado, for the dwelling houses of Mr. Eddie Bennett and Dr. R. Powell (9 and 10, fig. 1, and fig. 3), standing directly in the pathway of the tornado, were practically leveled to the ground, including the brick foundations. There were six people sleeping in the Bennett home, all of whom escaped serious injury, almost miraculously it would seem. The front of the house was blown eastward into the street lodging against a shade tree (fig. 4), the back of the house was forced backward toward the west into the garden, and the top of the house was carried northeastward. The lower floor of the house was inverted. Apparently this house exploded, a rather common phenomenon in the case of buildings caught in tornadoes. Mr. Bennett was sleeping on the lower floor with his small son and was aroused to find that he and the bed had changed their respective positions. In the overturning of the floor the bed had been overturned on him. He was nearly half an hour in making his way out from beneath the wreck.

The Dr. Powell house was located adjacent to Mr. Bennett's on the north. The dining room and kitchen were displaced, the remainder of the house was completely wrecked. A baby 7 weeks old sleeping between the mother and father was instantly killed, having been struck on the head by a heavy object. The mother was seriously injured, and the father sustained slight bruises. The two other children were not hurt.

The metallic shingles of the Powell house, readily recognized by their green color, were driven into trees nearly 1 mile from the house to the northeast. Several were picked up at a distance of 9 miles to the northeast of Gretna, and later, observers reported having seen the shingles 30 miles northeast, in Campbell County. Heavy window weights were carried a distance of 1½ miles from the house.

After the destruction of the two homes just described the tornado suddenly shifted its direction from north to northeast. In this direction it first encountered the home of Mr. J. E. Bennett (15, fig. 1) which was shifted backward from its foundation for a distance of 8 feet, leading the occupants to believe that the house had been struck by lightning. Here two interesting occurrences illustrate the freakish features so often observed in the paths of tornadoes. A post firmly embedded in the hard ground to the depth of 2 feet or more was lifted clear of the surface without being damaged, A house cat was picked up and carried a mile, finally being deposited in a tree, where its lifeless body was seen hanging the next day, its nine lives having been insufficient to survive its experiences while in transit.

The Christian Church of Gretna (11, fig. 1), a large building substantially constructed of boards, was directly in the path of the tornado and was completely destroyed (fig. 5). The boards and heavy timbers were strewn for one-half a mile across the fields to the northeast. The heavy plank floor was lifted up and rotated through an angle of 15° with respect to the foundation. The heavy stoves were carried 800 feet, and pieces of the church organ were found three-fourths of a mile away.

The home of Mr. D. V. Adams (12, fig. 1 and fig. 6), a modern brick structure, suffered severely, the front of the house being removed almost entirely, together with the roof. Mr. Adams, with his wife and small child, had retired for the night, their sleeping room being in the rear of the house on the second floor. They were awakened by a terrific crash. Mr. Adams arose, thinking that the house had been struck by lightning. Upon discovery that it was raining very hard he went to the window to look out. His wife urged him to retire again, saying that there was nothing he could do, as the house had not been set on fire by the lightning. He noted a peculiar odor as if quantities of fine dust had been blown into the room, and a minute later he found that the ceiling of the room was leaking in one corner. Deciding to investigate further he stepped through the bedroom door into the front of the house to find himself standing in the open air.

The roof of the Adams house was carried for a distance of one-half a mile and dropped in a gully. A large portion of the family wardrobe was carried three-fourths of a mile northeast into the woods and left hanging upon the trees. Bed quilts were blown 1½ miles to be carefully spread out without being torn. A brick from the house was blown through the thick board wall of the Methodist Church, 500 feet to the north-northeast, and displaced a pew some 3 or 4 feet from its original position. The Episcopal Church, 150 feet farther northeast, was moved slightly and the interior damaged. Fortunately it and the Methodist Church were east of the main path of the tornado, otherwise they would have experienced the same fate as the Christian Church.

From the Adams home the tornado passed northeastward across open fields to the north of Gretna, leaving a path strewn with every conceivable object—wreckage of buildings, household furniture, cooking utensils, clothing, etc. From these fields it entered a strip of woods three-fourths of a mile northeast of the village. Its track through the woods may be easily seen from a distance even with the dense foliage of summer on the trees. Nearly every tree in its path was felled, many being twisted off. The position of the tree trunks afford an excellent indication of the direction of the air currents in the tornadic whirl. Many of the trees on the right side of the path have fallen inward and slightly forward in the direction in which the tornado was moving. On the opposite side a number of trees have fallen inward also, but they tend to point backward in the direction from which the tornado came. This well illustrates the circular motion of the air currents in the tornado and their counterclockwise direction.

Little destruction was effected beyond this strip of woods. Its path may be traced across the Southern Railroad near the Sulphur Spring, a mile northeast of Gretna, and into the woods on the opposite side of the tracks. It seems then to have lifted, dipping down here and there to the surface again. In one of these downward dips 8 or 10 miles northeast of Gretna a house was unroofed and a log blown across the bed of a man sleeping on the second floor. Not far distant a tobacco barn was likewise uncovered with the added interesting feature that the tobacco with which the barn was filled at the time was completely lifted out and carried onward. In one corn field a number of ears were neatly husked and a quantity of stalks blown into the neighboring woods.

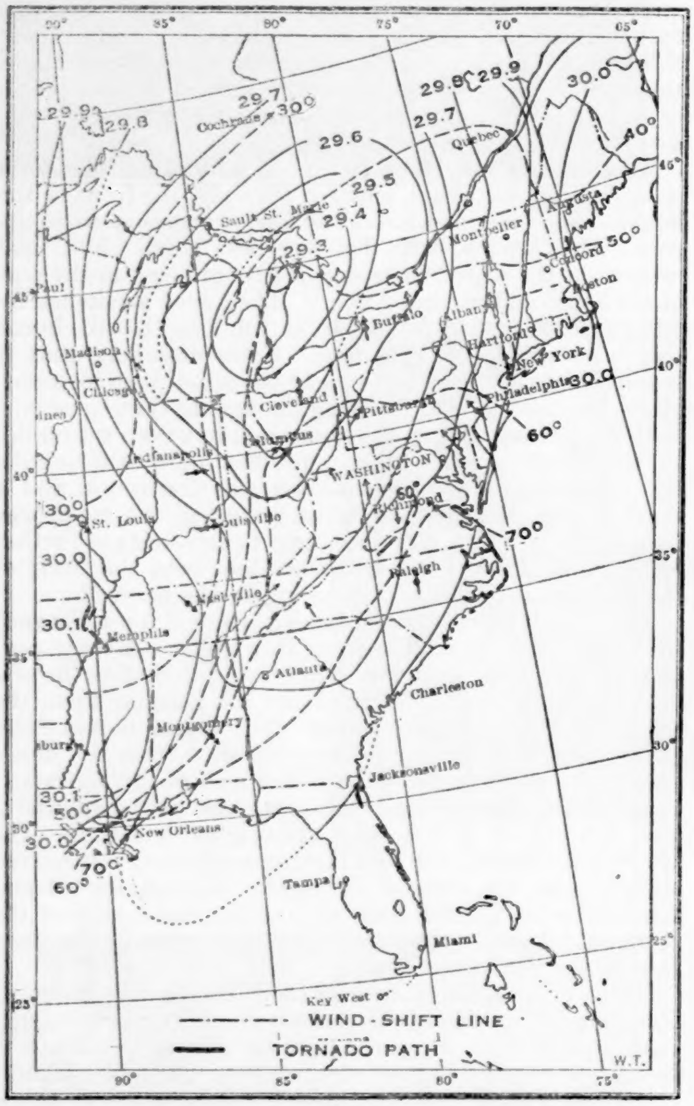


Fig. 7.—Weather map, 8 p. m. October 29, 1917.

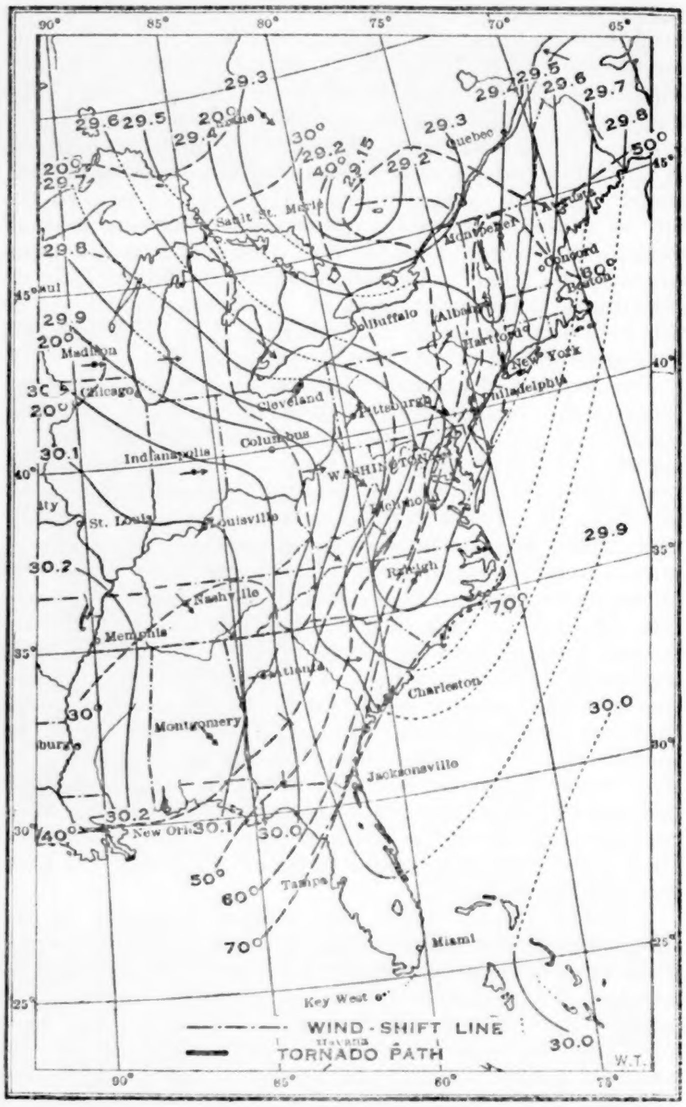


Fig. 8.—Weather map, 8 a. m. October 30, 1917.

The noise of the passing tornado was heard at Gladys, a small town located 20 miles northeast of Gretna, frightening those people who had not retired. No damage was done, as the tornado was apparently several hundred feet above the earth's surface at the time. It was also reported east of Lynchburg where it was heard passing overhead shortly after 11 o'clock.

Buildings in Gretna not in the direct path of the tornado suffered slight damage from the strong lateral currents that accompany a tornado. The railroad station (13, fig. 1) had a section of its roof removed, and the Virginia Hotel (14, fig. 1), across the railroad from the station, had a small part of its roof torn up. The Masonic Temple was almost completely unroofed and the rear portion of the large warehouse of Shelton Bros. was removed. All of these buildings were east of the main path pursued by the tornado.

The noise of the tornado in its rapid passage through the village awoke a number of people. All accounts agree that it resembled most closely the roar of a fast limited train passing along the Southern Railroad at full speed. Scarcely a full minute elapsed from the time the roar of the tornado was first heard until it had died out in the distance. This would indicate a speed of 60 miles or more per hour.

The day had been unusual in some respects. It was bright and warm, excessively warm for the time of year. At 4 p. m. thundercaps began to form and by sundown it was quite cloudy with a close sultry atmosphere. A little later it cleared and a warm and gentle springlike wind began to blow. About 9 p. m. a severe windstorm was experienced which persisted for some time. At 10 o'clock the first thunder was heard, accompanied by sharp lightning; however, it did not begin to rain until just

before the time of the tornado, 10:40 p. m. The passage of the tornado was accompanied by a terrific downpour, the noise of which tended to deaden the roar of the tornado. This heavy rain continued for some time afterward and gradually slackening ceased altogether before midnight. The sky remained clouded for the rest of the night, the clouds hanging low and driving fast before a hard wind that followed the storm and persisted throughout the remainder of the night. After midnight it grew colder rapidly and the next day there was a light fall of snow.

DISCUSSION.

Since this tornado was followed by a sharp fall in temperature at the passage of the wind-shift line of a marked V-shaped cyclone (see figs. 7 and 8) it would be natural on first thought to explain the storm as the result of cold air running over the mountains in advance of the wind-shift line at the earth's surface, and entrapping below it some of the warm, moist air on the Piedmont. This would cause intense local convection, and the result-

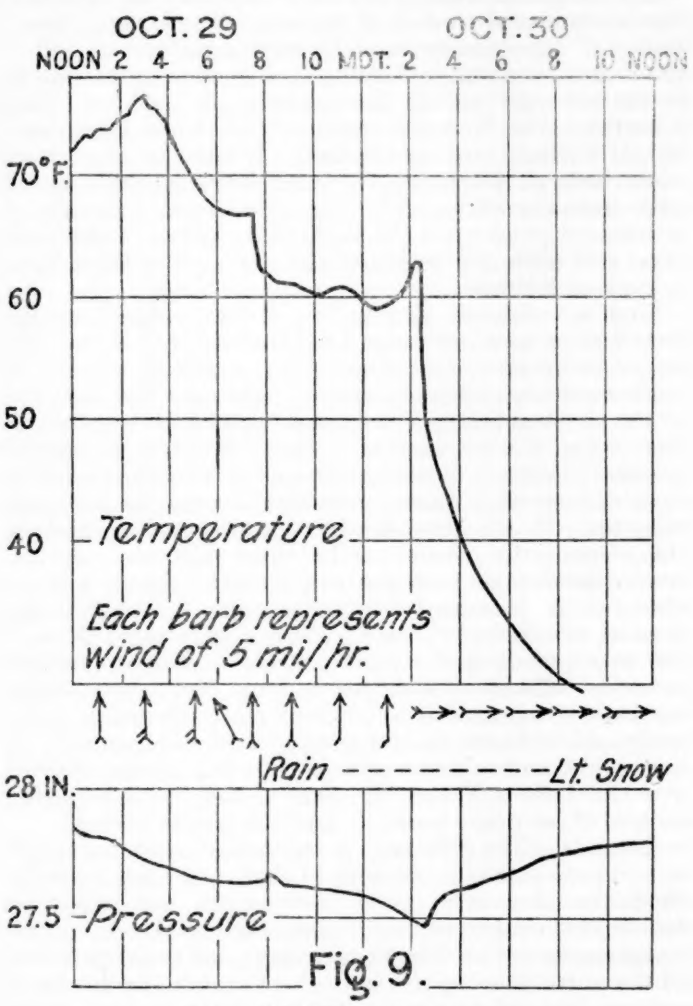


Fig. 9.
ELKINS, W. VA.

ing turbulence might be sufficient to produce a tornado.

Such an explanation, however, does not seem to be justified by the facts. At Lynchburg, about 40 miles north-northeast of Gretna, there was no rise in pressure till 7 hours after the storm (see fig. 10), although some humps in the pressure curve might legitimately be expected if a considerable stratum of cold, dense air arrived aloft. At Elkins, W. Va., rain began at 7:40 p. m., the temperature fell 6° F. at about 7:50 to 8:00 p. m., and there was a temporary, sharp rise in pressure amounting to 0.03 inch at about 8 p. m. (See fig. 9.) This is the only intimation that there may have been a cold wind front aloft which could have reached Gretna at the time (10:40) the tornado occurred.

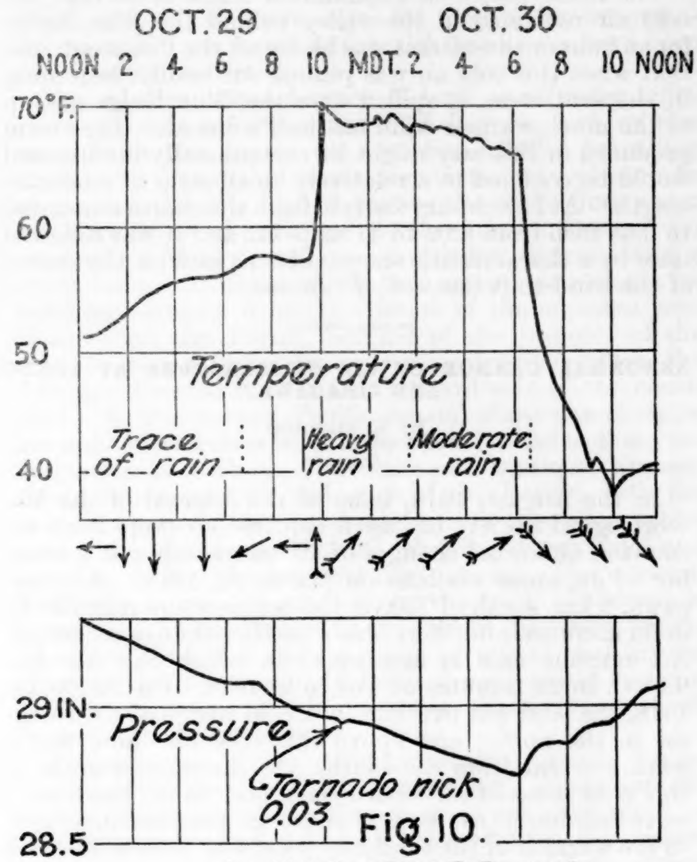


Fig. 10.
LYNCHBURG, VA.

Other conditions indicate that this tornado may be explained without assuming the arrival of a widespread cold wind running over the mountains. The stagnant cool air left from the anticyclone which was over this region the 28th was dissipated rather slowly; and at Lynchburg and probably westward to beyond the Blue Ridge some of this air remained till the evening of the 29th. (See fig. 7.) It is evident from the high temperatures and southerly winds at all surrounding stations, and from the cloudiness and light rainfall at Lynchburg during the day, that the warm, south wind was riding over this mass of cool air. Gretna seems to have been on the southern edge of the stagnant air until shortly after sunset, when "it cleared and a warm, gentle, spring-like wind began to blow." This light wind riding up over the cold air still at Lynchburg probably made the rainfall beginning there at 9:05 p. m.

At about 9 p. m. a severe windstorm of several hours duration began at Gretna; and 25 minutes later this wind reached the surface at Lynchburg, causing a remarkably rapid rise of temperature (see fig. 10).* When the temperature had reached its maximum of 70° F. at Lynchburg the first thunder was heard at Gretna (10 p. m.), and 40 minutes later the tornado occurred there. Whence came the cold air necessary to produce such an

*Cf. abstract on next page.

intense thunderstorm and tornado? The cold air which was over the Piedmont around Lynchburg could not have ridden back over the advancing southwest wind and produced a thunderstorm coming apparently *from* the southwest. Anyway, there is normally little opportunity for such cold surface air to get above any of the overrunning warm air.

The most reasonable explanation seems to be that the cold air remained in the valley behind the Blue Ridge for an hour or two after it was blown off the Piedmont, and that when this cold air was pushed out bodily, beginning in the southwest, it spilled over the Blue Ridge on top of the much warmer wind on the Piedmont. The storm produced in this way might be exceptionally intense and would be confined to a relatively small strip of moderate length. At Lynchburg the rain from this storm amounted to 0.58 inch from 9:05 to 11:45 p. m., and it was followed later by a characteristic shower of 0.13 inch on the arrival of the wind-shift line.—*C. F. Brooks.*

ABNORMAL CHANGE OF AIR TEMPERATURE AT TOKYO AND SINAGAWA.

By K. SIGETOMI

[Abstract.]

In the August, 1918, issue of the Journal of the Meteorological Society of Japan (pp. 49–54) there is an account of abnormal changes of air temperature at a number of Japanese stations on March 20, 1918. At Sinagawa, 9 km. south of Tokyo, the temperature rose 7.8° C. in 50 minutes, and there was a smaller change at Tokyo. An extreme case is mentioned in which the rise was 9.8° C. in 20 minutes at Tokyo in 1912. On March 20, 1918, the land was overlain by a cold wedge of air, thickest in the north; and above this cold air there was a warm current from the south. As the outer margin of this cold mass of air varied back and forth; there were correspondingly extreme changes in temperature—now to the warmth of the southerly wind and then to the cold of the northerly one. The morning weather map and the thermograph and wind records at 10 stations are reproduced.

Discussion.—Sudden rises in air temperature not infrequently accompany the arrival of a warm wind, the lower boundary of which has gradually descended till it reaches the surface with apparent abruptness. Similarly, if a wedge of cold air is slowly pushing under a warm wind, there will be an abrupt fall in temperature when the cold air arrives. On the boundaries between such currents there is usually a mixture fog. The persistence of the occurrence of such abrupt changes for a period of many hours shows how slowly two currents of air of radically different temperatures affect one another when the denser one is below the lighter. For some notes on similar occurrences in the United States, see (1) page 463 of this issue of the REVIEW, (2) note on Three ice-storms, Science, August 8, 1913, and (3) Ice storms of New England, Annals, Obs. Harv. Coll., volume 73, part 1, 1914.—*C. F. B.*

MAJOR CONTROLS OF THE CLIMATES OF THE UNITED STATES.[1]

By ROBERT DE C. WARD, Professor of Climatology, Harvard University.

Climate in general.—Climate is accurately and briefly defined as *average weather*. But means, or averages, may be made up of very different values of the elements which go into them, and therefore a satisfactory presentation of climate must include more than mere averages. It must also take account of regular and irregular daily, monthly, and annual changes, and of the departures, mean and extreme, from the average conditions which may occur at the same place in the course of time. This extension of the definition of climate is especially important in any region where irregular cyclonic variations of weather conditions are frequent, as in the so-called "temperate" latitudes of both northern and southern hemispheres. Therefore, just as weather types change from day to day, and from season to season, under varying controls, so climate is the resultant of many variables. One climate differs from another because of a different combination of these controls. While it is a relatively simple matter to enumerate the factors which combine to produce any given climate, it is difficult, if not impossible, to determine, quantitatively, the relative importance of these different controls, so intimately are they connected and so complex are their effects.

The major controls of climate.—The sun is obviously the fundamental control of climate. The general distribution of temperature over the earth's surface, as well as the diurnal and seasonal changes, depend upon variations in the intensity and in the duration of sunshine. This solar control of climate is commonly known as the control by (1) *latitude*, and stands first. If the sun alone were concerned, all places on the same latitude circle would have the same climate,[2] for the intensity and amount of sunshine depend upon the angle of incidence of the sun's rays, and upon the length of the day, and both of these depend on latitude.

Such a condition is very decidedly modified by the distribution and influence of (2) *land and water;* (3) *mountain barriers*, (4) *altitude*, (5) *prevailing winds*, (6) *ocean currents*, and temporary (7) *storms*. The reaction of the physical features and conditions of the earth's surface upon the atmosphere results is what is termed *physical climate*. According to the dominant control in each case we may have *continental*, *marine*, or *mountain* climates. In the first, land is the essential control; in the second, the ocean; in the third, altitude. An extreme development of the continental type is a *desert* climate. A transitional type between continental and marine, is a *littoral* climate.[3] The relative importance of the above-mentioned major controls of climate, and the types of climate which result from their interaction, inevitably vary greatly in different places according to the geographical location, and the physical, topographic, atmospheric, and other conditions peculiar to each district. For the United States the outstanding facts regarding each of these major controls are here briefly stated.

Latitude.—The difference in latitude between the northern and the southern portions of the United States is the fundamental control which determines the important fact that the mean annual, the seasonal, and the monthly isotherms as a whole show prevailingly lower temperatures in the north than in the south.[4] Yet these isotherms do not run east and west across the continent, as they would were latitude the sole control. Their deflections from the latitude lines show the influence of other controls, such, e.g., as land and water, mountains, ocean currents, winds. If winds have a free sweep across a country they inevitably

[1] Read before the American Climatological and Clinical Association, Boston, Mass., June 5, 1918.

[2] *Solar climate* is the term for a climate which is controlled solely by the amount of solar radiation which any place receives by reason of its latitude alone.

[3] For fuller details regarding the characteristics of these different types of climate, see R. De C. Ward: "Climate considered especially in relation to man," 8°, 2d ed., New York and London, G. P. Putnam's Sons, 1918.

[4] See, e. g., the charts of monthly and annual isotherms in Bartholomew's "Atlas of Meteorology," 1899, Pls. 7 and 8; also the mean annual, January and July isothermal charts in the series of "Climatic Charts of the United States," U. S. Weather Bureau.

wipe out climatic boundaries. They import heat and cold from a distance, and often to a marked degree—sometimes even completely—nullify the effects of latitude. While it is, therefore, impossible to give any quantitative estimate of the importance of latitude as a climatic control sunshine, here expressed by the term *latitude*, must be placed first in the list of major controls.

Land and water.—The influence of latitude may be wholly overcome by the effects of land and water. Land and water are fundamentally different in their behavior regarding absorption and radiation. Land areas, and the air over them, warm and cool readily and to a considerable degree. Water areas, and the air over them, warm and cool slowly, and relatively little. In the same latitudes, disregarding possible permanent differences in cloudiness, the insolation received at the surface on land and water surfaces is much the same. The differences in absorptive power of different land areas, also of water surfaces in various conditions of disturbance or quiescence, may be quite noticeable. However, the absorbed heat penetrates to but slight depths in the case of land surfaces, and because of the low specific heat of earth materials, especially when dry, the surface temperature of land areas increases greatly under insolation. Since the coefficient of radiation is comparable with that of absorption, the loss of temperature under cooling conditions is considerable. In contrast to this, the heat absorbed by water surfaces may penetrate to considerable depths, which, coupled with the very high specific heat of water, causes but slight change of temperature under either heating or cooling conditions.

The larger continental areas of the middle and higher latitudes, therefore, have great seasonal fluctuations in temperature. They are distinctly radical in their tendencies. They absorb much heat, but part with it readily. The oceans, on the other hand, are conservative. They warm but little during the day, and in summer. They cool but little during the night, and in winter. They take in little heat, and part with it reluctantly. Conservatism in temperature is a distinctive feature of marine climates. Another essential difference between oceans and continents is that the waters of the oceans are almost constantly in motion while the lands are stationary.

The temperatures of the oceans in higher and in lower latitudes thus tend to become equalized. This process results in keeping the waters near the Equator from becoming as warm, and those away from the equator from becoming as cold, as they otherwise would be. The land masses, on the other hand, have to take the temperature appropriate to their latitude and season. It follows, therefore, that North America as a whole is cooler in winter and warmer in summer than the adjacent oceans in similar latitudes. This is clearly shown on the isothermal charts for January and July.[5] In the average for the year, the lower latitudes of North America are warmer than the adjacent oceans in similar latitudes, while the higher latitudes are colder. It is obvious that when an isotherm crosses both land and water areas it is likely to be deflected, poleward or equatorward, according to the surface, whether land or water, over which it passes. Differences in climate along the same latitude circle necessarily result.

It has been of very great importance in the history of the United States that the North American continent broadens to the north and narrows to the south and does not become narrower in middle and higher latitudes as South America does. The races which have migrated from Europe to make up the American people have thus been able to spread over a vast extent of country in the Temperate Zone, having climatic conditions not very unlike those of their Old World homes. Were the continent broadest to the south, in the trade wind zone, an American Sahara would replace the Gulf of Mexico and the great agricultural regions of the United States would be correspondingly less extensive. The usefulness of North America as a new home for the overflowing populations of Europe would under such conditions have been very greatly restricted.

The relative preponderance of land or of water influences depends upon a number of factors, such as distance from the ocean; the direction of the prevailing winds; the presence of mountains in the way of onshore winds, etc. In the United States, the controlling water areas are (*a*) the Pacific and (*b*) the Atlantic Oceans; (*c*) the Gulf of Mexico, and, to a much less degree, (*d*) the Great Lakes. Neither of the two oceans can attain its maximum control over the climate of the adjacent continent—one, the Pacific, because of the presence of the massive mountain barrier near the coast; the other, the Atlantic, because it is on the leeward side of the continent. In the narrow Pacific coastal slope the climates are unlike those elsewhere in the country, and in many respects resemble those of western and southern Europe. Being exposed to the influence of the Pacific, with the prevailing winds blowing directly from the conservative ocean, the climates are on the whole relatively mild and equable, with slight seasonal fluctuations. The seasonal contrasts are most marked where the marine influence is lessened, as in the valleys to the east of the Coast Range. The Slope thus has various types of transitional littoral climates, with increasingly marked continental features over the sections which are most effectively shut off from the ocean influences.

The influence of the Atlantic Ocean is much diminished by the fact that the "prevailing" winds are offshore. Hence it follows that there is not very much of the tempering effect usually associated with the conservative ocean waters. The Atlantic coastal belt, except when the winds temporarily blow onshore, does not differ very much from the interior. This is clearly seen on the chart of mean annual ranges of temperature. Fairly large ranges, characteristic of a continental interior, are carried eastward to the coast, and, even over the ocean, for some distance offshore.[6] Thus the summers are warm along the Atlantic coast, and the winters are cold. The climate is not littoral; it is continental. The Southern States naturally have milder winters than do the States along the northern Atlantic coast, owing to the lower latitudes and the greater frequency of warm winds in the south. The importance of the Atlantic Ocean as a source of water supply is, however, very considerable. To the water vapor brought from the Atlantic by easterly storm winds the abundant and well-distributed rainfall of the Eastern States is largely due. The increase in the mean annual rainfall from the interior toward the Atlantic Ocean, and the general parallelism of the rainfall lines with the Atlantic coast, indicate that much of the water vapor must be supplied from this ocean.

The Gulf of Mexico is an important control of the climates east of the Rocky Mountains. It occupies latitudes which in the Old World include the Desert of Sahara. It is a very warm body of water.[7] Its maxi-

[5] See footnote, p. 464.

[6] See Atlas of Meteorology, pl. 2, text p. 8.

[7] The mean surface temperature in February averages between 68° and 77°, and in August, between 82.5° and 84°.

mum effects are seen during the summer months, for then the prevailing winds over most of the eastern United States are from southerly (SE., S., SW.) directions. These winds are well laden with vapor, and it is to them that much, if not most, of the summer rainfall over this eastern area is due. Furthermore, throughout the year and especially in winter, temporary warm and damp winds associated with passing storm (cyclonic) conditions, blow with considerable frequency from southerly directions, and thus carry the warming influence of the Gulf of Mexico far northward. These warm spells temper the winters of the northern districts, interrupting the severe cold that comes with the westerly and northwesterly winds from the northern continental interior. In summer, these southerly spells are hot, muggy, and depressing. The sharp contrast between the weather type which is associated with cold northerly winds, and that which comes with warm southerly winds from the Gulf, is one of the striking and characteristic features of the climates of much of the great region east of the Rocky Mountains.

The Great Lakes are of relatively subordinate importance as major climatic controls, but they show local effects which are in many cases of distinct economic significance. The lee shores in several cases show heavier annual rainfalls than the windward shores, but the excess is relatively rather slight, being generally not over 5 inches. The effect is probably greatest in the case of Lake Superior. Local topography is here, as always, an important factor in controlling the amount of rainfall. The belt between the 30-inch and the 35-inch mean annual rainfall lines shows a rather significant widening toward the Lakes. This fact, together with the general trend of these, and other, rainfall lines in the Great Lakes region, indicates that the Lake influence is present, although not very striking. The rain-bearing winds in this district are to a considerable extent from easterly directions, and for that reason the slight difference in rainfall between windward and leeward shores is not surprising. In winter, when the cold westerly winds sweep across the open waters of the Lakes, the snowfall on the lee shores is distinctly increased. Other effects of the Great Lakes are the decreased intensity of severe winter cold waves resulting from the tempering influence of the water; the later occurrence of the first killing frost of autumn and the earlier date of the last killing frost of spring in favored localities, as in the famous Chautauqua grape belt; the development of onshore lake breezes on fine hot summer days, as studied at Chicago; a local increase in cloudiness and in relative humidity, and some other minor effects. Details concerning these conditions belong in a study of local climates, and are out of place in a very broad consideration such as the present one.

Mountain barriers.—Mountain ranges, especially high and extended mountain ranges, are effective climatic barriers. If they stand in the path of the prevailing winds they may bring about marked differences in rainfall; in temperature; in cloudiness; in humidity, on their opposite sides. When near a coast, especially a windward coast, they prevent ocean influences from extending inland.

The most important mountain barrier in the United States is that formed by the Pacific Coast ranges (Cascades, Sierra Nevada, Coast). These western mountains prevent the influence of the Pacific from being carried far into the continent, and thus separate a narrow coastal belt, much of which has a modified marine climate, from an interior east of the Sierra Nevada-Cascades, where the rainfall is less and the ranges of temperature are much greater. The influence of the western barrier upon the climates of the North American continent as a whole is accentuated by the fact that the mountain systems trend in a northwesterly direction in the higher latitudes, where the continent broadens, thus limiting the marine influences still further to the more immediate Pacific coast. The situation is quite different in Europe, where there are no high west coast mountains and where for this reason, and because the windward margins of the continent are much indented by numerous water bodies, the ocean influence is carried far inland by the prevailing westerly winds. The Rocky Mountains, together with their collateral ranges, are far less important as a climatic barrier than they would be were there no Pacific ranges. The latter being farther to windward naturally have the greatest effect. The influence of the Rocky Mountains is seen in their local effects upon rain and snowfall; in their acting as a barrier against the spreading of cold waves over the Plateau region from the east; in the warming which bodies of air undergo as they descend the slopes (chinook winds); in the differences which often prevail between the weather types to the east and west of the continental divide, and in other ways.

The Appalachians as a whole are not an effective barrier. They are not high. They are near the leeward margin of the continent. They are more or less parallel to the direction of the prevailing winds during much of the year. The amounts of rainfall on their eastern and western slopes do not, taking the system as a whole, show very marked and persistent differences. Even in winter they do not protect the districts to leeward from invasions of continental cold. The Appalachians do, however, show many local barrier effects upon the climates of their immediate surroundings. The fact that the lesser mountain barrier is on the east of the continent and the greater barrier on the west, made it easy for the early settlers to cross the Appalachian area through the natural gateways, and then to expand over the great interior lowlands, where they found favorable climatic conditions.

It is one of the striking characteristics of the topography of the United States that there is no great transverse (i. e., east and west) mountain barrier. In going from south to north, or vice versa, no sudden changes in climate are met with. The gradations are slow and gradual. The climatic subdivisions are, therefore, separated by meridianal, and not by latitudinal, lines. The influence of the Gulf of Mexico would be much diminished if there were a transverse range of high mountains across the Mississippi valley. Such a range would cut off from the districts to the north of it the warm southerly winds and the rainfall which now have free access from the Gulf. The severity of the winters would, therefore, be considerably increased over the northern tier of States east of the Mississippi River. A transverse mountain range, on the other hand, would be a great protection to the Southern States in winter, in keeping out the cold northwest winds, which now have a free sweep from the western plains of Canada to the Gulf, and often cause great damage to crops in the far south. The significant fact concerning the topography of the eastern United States as a whole is its uniformity. There is some analogy here with the conditions over much of Europe, where the mild and damp southwesterly winds from the warm Atlantic temper the winters in a similar though much more marked way.

The fact that the western mountain barriers largely prevent the importation of water vapor from the Pacific Ocean into the interior of the country adds very greatly

to the importance of the control which the Gulf of Mexico can exert over the rainfall of the eastern United States in the absence of any transverse mountain barrier. From the Gulf comes an abundant supply of rainfall, which to a large extent compensates for the loss resulting from the presence of the western mountains. Were there no western mountain barrier, the Gulf, while still of importance, would be a less critical control. In Europe, where high western mountain ranges are lacking, the supply of water vapor from the Atlantic is freely distributed to the eastward, over the continent. There is, therefore, no such need of an auxiliary supply from the Mediterranean. If there were no Gulf of Mexico, or if there were a high transverse mountain barrier across the Mississippi Valley, the rainfall over much of the United States east of the Rocky Mountains would doubtless be far less favorable for agricultural purposes and for the homes of a large population. Indeed, it is probable that semi-aridity might to a considerable extent replace the present sufficient and well-distributed rainfall over much of our best farming land.

Altitude.—The barrier effects of mountains are simply due to the obstacle that mountain ranges put in the way of climatic conditions, which would otherwise be similar on the opposite sides of the barrier. A narrow wall, as high as the respective mountain ranges, would accomplish essentially the same results. In addition to this simple barrier effect, mountains and highlands have certain special climatic peculiarities because of their elevation above sea level. It is here that the control of climate by *altitude* is met. Mountain and plateau climates are always placed in a group by themselves as distinguished from those of lowlands. The former, as contrasted with the latter, are characterized by a general decrease in pressure, temperature, and absolute humidity, an increased intensity of insolation and radiation, larger ranges in soil temperature, higher wind velocities, usually a greater frequency of rain and snow and, up to a certain altitude, more of it. "Inversions of temperature" (i. e., where the temperature increases with increasing altitude) are frequent characteristics of the colder months and of the night. Such conditions often give mountains the advantage of higher temperatures than the adjacent valleys or lowlands—a fact of importance in connection with the use of certain mountain stations as winter resorts. In summer, altitude gives relief from the heat of the lowlands.

Broad generalizations such as these serve only for the purposes of a very brief summary. The local topography is of prime importance in bringing about many modifications in climatic conditions. Mountains both modify the general and give rise to local winds. Among the latter, the well-known mountain and valley winds are often of considerable hygienic importance in their control of the diurnal period of humidity, cloudiness, and rainfall. In the United States the greatest and most widespread effects of altitude are naturally found in the western plateau and mountain region, where the varied topography gives rise to a great variety of local climates. In the east the elevations are less, and the area occupied by highlands is less extended. Nevertheless, there are many well-known conditions which result from the presence of mountains. Among these may be mentioned, as illustrations, the heavy rainfalls of the eastern and southern slopes of the southern Appalachians; the popularity, as summer resorts, of the White Mountains of New England, the Adirondacks of New York, and many other portions of the mountain and plateau country along the Atlantic seaboard. If there had been no Appalachian highland area in the Southern States, with its plateaus and slopes unsuited to the growth of tobacco and cotton and sugar cane, these typical southern crops, and the negro labor which they necessitate, would doubtless have occupied much of the area which, with its more "temperate" plateau and mountain climates, was actually settled by a very different sort of population, engaged in different occupations.

Prevailing winds.—Most of the United States lies in what is generally known as the belt of the storm-bearing "prevailing westerly winds." To the south, the States bordering on the Gulf of Mexico, already subtropical in latitude, share also in the wind system which is characteristic of tropical countries, viz, the trades. These trade winds, like the "prevailing westerlies," find their initial cause in the great permanent differences of temperature and of pressure between equator and poles, but are greatly modified by local pressure distribution. Year by year the orderly succession of the seasons brings a warming and a cooling of the continent. The pressures change systematically, not only over the continent, but also over the adjacent oceans. Sympathetically, also, the prevailing winds show a seasonal change in their directions. Other influences also play a part. The great mountain systems are barriers in the path of the winds. The general configuration of the country—the trend of mountains and of valleys, locations to windward or to leeward of mountains or of lakes, the hour of the day or night, exposure to land or sea breezes, and, more important than all, the varying storm control—all these have a share in controlling the winds, both in direction and in velocity. And as winds are of critical importance in controlling weather types, their direction and velocity, however controlled, are fundamentally important in any study of climate. The "prevailing wind" in summer may be a very warm one, as is the case over most of the eastern United States, where southwesterly wind directions are dominant during the hot months. Such conditions naturally increase the summer heat. Or, the prevailing winter wind may be a cold one, as in New England, thus making the winters more severe. The reversal of the "prevailing westerly winds" under the control of passing conditions of high or low pressure is so frequent that many persons, especially along or near the northern Atlantic coast, find it difficult to believe that the "prevailing winds" are actually from the west. Easterly storms, easterly winds blowing on shore from a high pressure area off the coast, even the local and relatively insignificant sea breeze of summer, all combine to keep up this impression.

The great permanent areas of high and of low pressure over the oceans adjacent to North America—the so-called "centers of action"—play a considerable part in determining the directions of the prevailing winds on the continent. The low pressure system over the northern North Atlantic ("Iceland LOW") exerts a marked control over the prevailing northwesterly winds of the northeastern United States in winter. The tropical high-pressure belt of the North Atlantic has an important share in determining the great flow of southerly winds over the southern and eastern portions of the country throughout the year, as well as in controlling the general character of the seasons in the eastern United States. On the Pacific coast, a low-pressure area over the northern North Pacific ("Bering Sea or Aleutian LOW") in winter largely controls the prevailing southwesterly and westerly winds of the northern portion of this coast, while the tropical high-pressure belt lying farther south

also influences the wind directions, especially along the southern portion of the coast.

Ocean currents.—Too much emphasis is usually laid on ocean currents as controls of climate. It should be remembered that an ocean current can have practically no influence on the climate of an adjacent land unless the wind is blowing onshore, and further that ocean waters in themselves, without the help of any ocean currents, are conservative bodies, and, therefore, tend to temper the cold or the heat of any land over which their influence may be carried. It is true enough that the Gulf stream and the Gulf stream drift do keep the North Atlantic waters off the eastern coast of the United States warmer than they would otherwise be, and that the Labrador current is a cold flow which chills these same waters to a lower temperature than they would otherwise have. And on the Pacific side, the Japanese current, flowing southeastward along our western coast, with a subordinate eddy circling around the Bay of Alaska, certainly contributes toward keeping the Pacific slope climates rainier and warmer in winter than they would be without that current. A glance at the isothermal charts of the world at once shows the effects of these currents in deflecting the isotherms. Off the Pacific coast of North America, the isotherms are carried equatorward by the southward-flowing current passing along California and Mexico, and poleward by the eddy which flows from right to left around the Bay of Alaska. The result is a spreading apart of the isotherms and a tendency toward an equalization of the temperatures along the coast. On the Atlantic side, on the other hand, the isotherms are crowded together. The Gulf stream carries them northward along the southern and central portions of the coast, while the Labrador current carries them southward along the coast of New England and the Canadian Provinces. Hence there is a very rapid decrease of temperature northward along the Atlantic coast, which amounts to 2.7° F. per latitude degree in January.

Storm control.—In the "Temperate Zones" the weather is largely controlled by a succession of low and high pressure areas ("cyclones" and "anticyclones"), more or less irregular in their occurrence; uncertain in their progression and direction; and differing considerably in their characteristics. Hence, weather changes are correspondingly irregular, uncertain, and diverse. Of weather types there is an almost endless variety. These different types give our climates their distinctive characters, and to a large extent determine the amount and distribution of temperature; of rain and snow; of humidity; of cloudiness. Cyclones and anticyclones are, therefore, essential controls of climates in the latitudes of the "prevailing westerlies." Over the Temperate Zones as a whole there is a great ring of stormy weather, oscillating poleward and equatorward as the sun moves to and fro in the course of its regular migration. In winter, practically the whole of the United States is under the influence of this storm belt. Storms are not only more widely distributed then, but they are also larger, more frequent, more violent, and move faster than in summer. Hence, all changes of wind, temperature, and weather occur oftener, are more sudden and more emphatic at that season. In summer, when the general storm belt swings to the north, the storm element in our weather changes is weakest. The dominant weather types are chiefly associated with the regular changes from day to night. Periodic, diurnal phenomena replace nonperiodic, cyclonic phenomena. The detailed study of weather types is not a part of ordinary climatological investigation. Yet anyone who seriously attempts to study the climatology of the United States should have a series of weather maps in one hand, and a set of climatic charts of the country in the other. He will soon realize that the better his understanding of the former, the more intelligent is his appreciation of the latter.

SECTION III.—FORECASTS AND WARNINGS.

FORECASTS AND WARNINGS, OCTOBER, 1918.

By ALFRED J. HENRY, Supervising Forecaster.

[Dated: Washington, Nov. 30, 1918.]

PRESSURE IN THE NORTH PACIFIC AND ALASKA.

A depression of the barometer passed over Midway Island on the 1st and the barometer was below normal from the 17th to the 23d; at all other times pressure was above normal. Pressure was below normal at Honolulu practically throughout the month. It was also below normal in the Gulf of Mexico and the Caribbean region and indeed along the Gulf coast and the southern border of the United States. In Alaska pressure was below normal in the coastal regions and the Yukon basin from the 3d to the 13th. This period of low pressure was followed by a week of high pressure, which apparently spread inland by way of the Aleutians and Nome to the interior, but not to the southeast coast or to the Canadian northwest. In the United States the fluctuations from the normal pressure may be seen from an inspection of Table 1.

THE WEATHER OF THE MONTH.

As might be inferred from the fact that the majority of lows of the month passed eastward along the northern border, some rather far to the northward, thus causing southerly winds, the month as a whole was a warm one. Killing frost was not experienced in the southern parts of the areas where the average date falls within the last decade of October.

Precipitation was deficient in Atlantic Coast States to the eastward of the Appalachians. The failure of rain east of the latter was one of the characteristics of the month. Heavy rains fell in the west Gulf States on the 26th and in the east Gulf States on the 29th, and there was a week of more or less general rains in the Gulf States in connection with the depression platted as No. VI on Chart III. On the whole it may be said that the month was warm, with about the average precipitation. The detailed figures appear in Table 1.

HIGHS.

Eleven HIGHS have been plotted on Chart II counting as a single HIGH those which appear to have merged in Manitoba or the valley of the Red River of tle North. If we ascribe the origin of these HIGHS to the Canadian northwest the number that originated in that region will total six while the remaining five were of the North Pacific origin. The following characteristics stand out clearly:

(1) The HIGHS were the dominating weather control of the month; nevertheless it is to be noted that the temperature was above the normal.

(2) There was more or less merging of North Pacific HIGHS with HIGHS which first appeared over the Canadian northwest. Just prior to merging, the barometer level in the Canadian HIGHS was no greater than in the North Pacific HIGHS, but shortly after merging the barometer level increased.

(3) There was a very well-defined increase in the barometer level in HIGHS as they passed over mountain districts, particularly the Green Mountains of Vermont and the northern Appalachians of West Virginia.

(4) The North Pacific HIGHS which did not merge passed off to the sea over the Atlantic, or dissipated in Southeastern States south of north latitude 40°, while the Canadian HIGHS invariably passed off to the sea northward of 40° north latitude; North Pacific HIGHS on the average were about six days in crossing the continent while the rate of movement of Canadian HIGHS was more rapid, as might be expected.

LOWS.

Thirteen LOWS, classed according to the geographic location of their entrance into or appearance as well defined LOWS within the field of observation, have been plotted on Chart III as follows: Alberta, 7; North Pacific, 2; Middle Rocky Mountain, 2; Southern Rocky Mountain, 1; Gulf of Mexico, 1. Almost without exception these LOWS were featureless and of little intensity. The tendency was almost always toward a diminution of intensity with eastward movement. No. XII of Chart III for a time gave promise of developing into a severe storm in the Lake region on the 27th, but while the barometer in the center fell as low as 29.12 inches on the morning of the 28th, only moderate gales were reported.

The true centers of Alberta LOWS were doubtless at some distance north of the field of observation and this fact may explain the apparent lack of intensity. A characteristic noted in previous months, viz, the tendency for a secondary depression to form in the southerly quadrants of Alberta LOWS, when for any reason the movement of the principal LOW is checked, was again noted in October. LOWS Nos. III, XI, and XII-A are examples of secondary depressions that developed to the south or southwest of the principal depression. The barometer was low practically the entire month in the Gulf of Mexico and the Carribbean region. On the morning of the 13th a shallow depression whose previous movement can not be traced with much certailty appeared off the mouth of the Mississippi. This depression was irregular in shape and generally without storm winds but was associated with fairly heavy rainfall in the Gulf States. It persisted nearly a week and finally seems to have passed inland merging with LOW No. VIII on the night of tle 19th–20th. Its approximate path is shown by No. VI, Chart III.

WARNINGS.

Storm warnings were issued for one or more of the Great Lakes on the 1st, 4th, 5th, 12th, 13th, 24th, 26th, 27th, and 28th, and for the east Gulf and Atlantic coast on the 5th, 15th, 18th, 20th, 23d, and 30th.

The warnings of the 5th and 13th on the Great Lakes and of the 20th and 30th on the Atlantic coast were not justified. In general the month was less stormy than the average.

Frost warnings were issued on various dates mostly for the northern portions of the district.

WARNINGS FROM OTHER DISTRICTS.

Chicago, Ill., forecast district.—The month as a whole throughout the Chicago forecast district was rather mild, with deficient rainfall in the northwest. The rainfall in the middle Missouri Valley thence southward exceeded the normal considerably.

So far as forecasts and special warnings are concerned, the month was uneventful, frost warnings especially being few because of the mild weather. For the most part, damaging frost did not occur until much later than usual.

Frost warnings were issued as follows:

On the 2d for Wisconsin, Iowa, and eastern Minnesota; on the 13th for eastern Wisconsin and northeastern Illinois; on the 24th for Iowa, western Missouri, and southern Nebraska; on the 27th for western Missouri, Kansas, and southeastern Nebraska; on the 29th for Missouri and Kansas; on the 30th for Illinois, Missouri, and Kansas; and on the 31st for Illinois and Missouri.

Warnings for freezing temperatures were issued as follows:

On the 26th for Nebraska and Kansas; and on the 31st for Wisconsin. Moreover, the warnings issued on the 27th were for either frost or freezing temperature.

In almost every instance these warnings for frost and freezing temperature were verified.

Special warnings were issued to the cranberry marshes on October 2, the last of the season, and heavy or killing frost was reported generally throughout the marsh region during the ensuing night. The cranberry harvest was completed by the 3d, except in the northwest portion of the State. There was a local heavy frost at the Mather station on the 2d for which a warning was not issued.

Because of the prolonged drought in the Minnesota forest region, extensive fires developed there so by the 18th a large area was included. In pursuance of a request from Col. L. D. Godfrey, of the Fourth Minneapolis Infantry, who had charge of all fire fighting and relief work in the fire zone, special wind and weather telegrams were sent to him at his headquarters at Moose Lake, from the 19th to the 24th, inclusive. By the latter date the fires had been extinguished because of the general rains and successful work of the fire fighters. Under date of October 24, the official in charge of the United States Weather Bureau office, Minneapolis, Minn., writes as follows:

Your prompt action in telegraphing the forecasts was much appreciated and the forecasts were of great help to the fire fighters.—
H. J. Cox.

New Orleans, La., forecast district.—The most important feature of the month was a storm area which appeared in the Gulf of Mexico off the Louisiana coast on the 15th and moved slowly northwestward during the 16th and 17th, passing inland off the mouth of the Sabine River on the morning of the 18th. Northeast storm warnings were ordered displayed, New Orleans to Velasco, on the afternoon of the 15th, were extended to Brownsville, Tex., on the morning of the 16th, and were continued at other stations on the Texas coast on the afternoon of that date. Warnings were changed to storm northwest on the Texas coast on the 17th, and were ordered down on the morning of the 18th. Verifying winds occurred at New Orleans and Galveston, and near verifying velocities at other stations, but, as a whole, the disturbance was of moderate intensity.

Storm northwest warnings were ordered displayed from Port Arthur to Corpus Christi, Tex., on the 26th and the warnings were justified.

The first frost of consequence occurred over the interior of the district on the 28th, for which timely warnings had been issued. Warnings were issued on the 30th for frost over the interior of the district, and on the 31st for heavy frost or freezing over the northern portion of the district and frost over the interior of the southern portions; heavy frost with freezing in some localities occurred over the northern portion of the district and frost over the interior of the southern portion by the morning of November 1.—*I. M. Cline.*

Denver, Colo., forecast district.—Warnings of frost or freezing temperature were made for one part or another of the district on the 6th, 11th, 16th, 17th, 18th, 19th, 23d, 25th, and 26th. Warnings of high winds were issued on the 28th. Both wind and frost warnings were generally verified.—*Frederick W. Brist.*

San Francisco, Cal., forecast district.—October, 1918, was comparatively a quiet month in this district, with temperatures above the normal in all sections. From the 28th to the end of the month unseasonably high temperatures prevailed in southern California and along the southern coast of northern California.

Rain was frequent in western Washington and northwestern Oregon, but the daily amounts were not large. In southern Oregon, California, and Nevada, except along the eastern slope of the Sierra Nevada Mountains, the precipitation was very deficient. In Idaho the precipitation was slightly above normal.

Killing frosts occurred in eastern Oregon, Idaho, and Nevada, but it is not believed that they caused material damage.

Storm warnings were ordered on the Washington and northern Oregon coasts on the 4th, 5th, 9th, 10th, and 27th; and small craft warnings from Cape Mendocino north on the 4th; for Marshfield north on the 11th; and on the Washington and Oregon coasts on the 20th, and 22d. There were no storms without warnings and all warnings are believed to have been verified.—*G. H. Willson.*

SECTION IV.—RIVERS AND FLOODS.

RIVERS AND FLOODS, OCTOBER, 1918.

By ALFRED J. HENRY, Meteorologist in Charge.

[Dated: Weather Bureau, Washington, Nov. 30, 1918.]

Heavy rains in upper Vermont and New Hampshire caused a moderate flood in the Connecticut River at White River Junction, Vt., but no damage resulted.

Rains were generally heavy throughout South Carolina, and in western North Carolina they were excessive during the last week of the month, causing most of the streams in the western portion of South Carolina to rise rapidly. In the mountainous districts stages of 5 to 8 feet above flood stages were reached. In the lower stretches of the rivers the crests were only slightly above flood stages. The greatest damage was done in the vicinity of Greenville and Spartansburg, where the loss is estimated at $270,000. The total loss for the State is estimated as follows: Buildings, factories, roads, bridges, $219,000; crops, $162,000; live stock, $6,000. The value of property saved by warnings is placed at $83,000.

In Georgia, the only places where a flood stage were reached was at Carlton, on the Broad River and Norcross on the Chattahoochee. No damage was reported.

Flood stages are of rare occurrence in the east Gulf States during the autumn; but the heavy rains of the latter part of October caused many of the streams in the Montgomery and Mobile, Ala., districts to overflow, and the streams in western Mississippi were about bank full. In the Mobile district loss to crops was estimated at $87,000; stock and movable property, $1,500; and wages, $1,500. It is estimated that property valued at $25,000 was saved by timely warnings. In Mississippi but little damage was sustained except through the washing of roads by heavy rains. This damage was estimated at $250,000.

Rains were excessive in the Asheville district—7.31 inches fell at Asheville and 6.62 at Penrose, N. C., during 24 hours ending 8 a. m. of the 25th. The river rose rapidly at these places and flood stages were reached as far down as Knoxville, Tenn. Roads and bridges were reported damaged to the extent of $14,000; crops, $9,000; and movable property, $250. Much property was reported as saved by timely warnings.

In the Cincinnati, Ohio, district, the New River was slightly above flood stage at Ivanhoe and Radford, Va.

In Texas, the Rio Grande was in flood at Rio Grande city on the 22d and the Guadelupe at Victoria on the 30th. The Trinity was above flood stage on the 24th and 28th. No damage reported.

The following report of the effects of heavy rains in the vicinity of Juneau, Alaska, during September, 1918, is submitted by Mr. M. B. Summers, meteorologist:

A disastrous flood occurred in the city of Juneau and vicinity on September 26, 1918, as a result of heavy rains during the 25th and 26th. Rain began shortly after midnight of the 24th-25th and continued without cessation until the early morning of the 27th, a total of 7.41 inches falling at Juneau during the 25th and 26th. The greatest 24-hour amount during this period was 5.54 inches from 5:34 p. m. of the 25th to 5:34 p. m. of the 26th, normal time. The fall was still heavier however, at Perseverance, 4 miles east of Juneau and at the head of Gold Creek, a stream that drains mountain slopes over 3,000 feet in height and that empties into Gastineau Channel through the tideflat section of Juneau. At Perseverance 7.40 inches of rain fell in the 24 hours ending at 4 p. m. of the 26th, and 2.80 inches in the preceding 24 hours.

As a result of these heavy rains, Gold Creek rose to flood height and overflowing its banks in its lower reaches, inundated a large part of the tideflat portion of the city. The height and swiftness of the current wore away the banks of the stream and changed its course somewhat, carrying away six dwelling houses. A number of other dwellings were flooded, as was also the hospital of the U. S. Bureau of Education from which patients and nurses were rescued in a boat.

The heavy rains also caused a slide on the slope of the mountain above Gastineau Avenue, on the opposite side of the city, which resulted in the destruction of four dwellings. A torrent of water followed the slide and flooded the Gastineau Hotel and W. R. Wills's store, these being at the foot of the slope and immediately below the houses destroyed. A number of slides occurred along the highway between Juneau and Perseverance, blocking that thoroughfare to such an extent that it probably can not be reopened before next summer. The Juneau city water system was put out of commission by slides that carried away a portion of the flume conveying water to the reservoir, thereby depriving the greater portion of the city of water for nearly a week. The same trouble was experienced by the Alaska Electric Light & Power Co., and as a result the city was without electric light or power for two days. As practically all power used in the city is electric, and there being no gas system, the loss and inconvenience from suspension of operation of the power plant was considerable. The Alaska Juneau Mining Co. suffered considerable damage to the electric railroad connecting the mine and the mill, a slide taking out a section of the steel trestle near the mill. The flume conveying the water supply of the mill was also damaged. The road to Thane was closed by slides and a bridge on the Mendenhall road carried away.

Fortunately no lives were lost, the effect of the rains being confined to damage to property, the suspension of mines, shops, and public utilities, and to the general inconvenience suffered by the public. Estimated monetary loss sustained, $175,000.

TABLE I.—*Flood stages in the North Atlantic drainage during October, 1918.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Connecticut:	Feet.			Feet.	
White River Junction, Vt.	13	7	9	14.5	8
Unadilla:					
New Berlin, N. Y.	8			7.5	31

TABLE II.—*Flood stages in the South Atlantic drainage during October, 1918.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Santee:	Feet.			Feet.	
Rimini, S. C.	12	28	(*)	16.2	31
Ferguson, S. C.	12	31	(*)	12.1	31
Catawba:					
Mount Holly, N. C.	15	27	27	16.0	27
Catawba, S. C.	11	27	28	18.5	27
Do.	11	31	(*)	14.2	31
Wateree:					
Camden, S. C.	24	28	(*)	30.5	28
Congaree:					
Columbia, S. C.	15	27	29	20.7	28
Broad:					
Blairs, S. C.	15	27	28	22.4	27
Do.	15	31	(*)	16.7	31
Saluda:					
Pelzer, S. C.	7	25	27	18.0	27
Do.	7	31	(*)	8.8	31
Chappells, S. C.	14	27	29	22.6	28
Savannah:					
Augusta, Ga.	32			29.8	27
Broad:					
Carlton, Ga.	11	25	25	13.5	25
Chattahoochee:					
Norcross, Ga.	16	31	(*)	18.1	31

* Continued into November.

TABLE III.—*Flood stages in East Gulf drainage during October, 1918.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Chattahoochee:	*Feet.*			*Feet.*	
Norcross, Ga	16	31	(*)	18.1	31
Coosa:					
Lincoln, Ala., lock No. 4	17	30	(*)	19.0	31
Etowah:					
Canton, Ga	11	30	(*)	18.9	30
Cahaba:					
Centerville, Ala	25	30	(*)	32.7	30
Tombigbee:					
Demopolis, Ala	39	31	(*)	42.1	31
Black Warrior:					
Tuscaloosa, Ala	46	31	(*)	51.3	31
Pearl:					
Jackson, Miss	20			19.3	31

* Continued into November.

TABLE IV.—*Flood stages in Mississippi drainage (Ohio Basin) during October, 1918.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
New:	*Feet.*			*Feet.*	
Ivanhoe, Va	15	26	26	16.0	26
Radford, Va	14	26	26	16.5	26
Narrows, Va	20			18.0	26
Tennessee:					
Knoxville, Tenn	12	27	27	12.0	27
Do	12	31	(*)	18.7	31
French Broad:					
Penrose, N. C	13	25	27	18.7	26
Do	12	29	(*)	19.5	30
Asheville, N. C	4	25	(*)	8.0	30
Dandridge, Tenn	12	30	(*)	14.0	30
Big Pigeon:					
Newport, Tenn	6	30	(*)	8.3	30
Holston, North Fork.:					
Mendota, Va	8	26	26	8.0	26
Do	8	30	(*)	9.0	30
Little Tennessee:					
McGhee, Tenn	20			19.6	30

* Continued into November.

TABLE V.—*Flood stages in West Gulf drainage, during October, 1918.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Trinity:	*Feet.*			*Feet.*	
Dallas, Tex	25	23	24	30.0	24
Do	25	27	29	29.0	28
Rio Grande:					
Eagle Pass, Tex	16			15.6	22
Rio Grande City, Tex	15	23	24	17.8	24
Guadalupe:					
Victoria, Tex	16	29	30	19.2	30

MEAN LAKE LEVELS DURING OCTOBER, 1918.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., Nov. 5, 1918.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.*			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during October, 1918:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	602.49	581.18	572.29	246.00
Above or below—				
Mean stage of September, 1918	−0.05	−0.32	−0.18	−0.20
Mean stage of October, 1917	−0.14	−0.16	−0.55	−0.68
Average stage for October, last 10 years	−0.14	+0.77	+0.21	+0.18
Highest recorded October stage	−1.07	−1.76	−1.41	−1.81
Lowest recorded October stage	+0.91	+1.58	+1.49	−2.33
Average relation of the October level to—				
September level		−0.2	−0.3	−0.4
November level		+0.2	+0.3	+0.3

* Lake St. Clair's level: In October, 575.50 feet.

SECTION V.—SEISMOLOGY.

SEISMOLOGICAL REPORTS FOR OCTOBER, 1918.

W. J. HUMPHREYS, Professor in Charge.

[Dated: Seismological Investigations, Weather Bureau, Dec. 3, 1918.]

TABLE I.—*Noninstrumental earthquake reports, October, 1918.*

Day.	Approximate time, Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		ARKANSAS.								
1918.	H. m.		° ′	° ′			M. s.			
Oct. 4	9 21	Bauxite	34 33	92 24		3		Loud	Like an explosion, followed by three bumps and rapid rocking.	Arkansas Gazette.
		Black Rock	36 08	91 02		1	20			S. J. Howe.
		Brinkley	34 53	91 07	5	1	Few	None	Abrupt trembling SE-NW	H. L. D. Whitson.
		Carlisle	34 47	91 39	5	1	10	Rumbling	Gradual rocking and trembling	J. F. Gillespie.
		England	34 32	91 52						Arkansas Gazette.
		Little Rock	34 45	92 06	5	3	06	Rumbling	Abrupt rocking N-S	R. E. Stevenson, et. al.
		Lonoke	34 47	91 49						Arkansas Gazette.
		Pine Bluff	34 13	91 54		1				W. P. McGeorge.
		Scott	34 43	92 01						Arkansas Gazette.
		Searcy	35 15	91 39	5		Few	Rumbling	A series of quivers; windows rattled, furniture moved.	Sarah Cypert.
13	10 00?	Black Rock	36 08	91 02	2	3	30	None	Three abrupt shocks	S. J. Howe.
	9 30?	Hoxie	36 03	90 55	5	1	30	Rumbling	Abrupt rocking N-S	J. E. Pringle.
	? ?	Jonesboro	35 51	90 39				None	Rocking	Benedictine Sisters.
	9 35?	Pocahontas	36 15	90 56	5	1	30	Rumbling	Gradual trembling N-S	Do.
16	2 11?	Hardy	36 19	91 21	3	1	30	Rumbling	Gradual rocking N-S	C. A. Caywood.
		CALIFORNIA.								
11	4 00?	Calexico	32 41	115 30	3	1	01	None	Abrupt lurch N-S	H. M. Rouse.
	3 45?	Hemet	33 44	116 58	2	1	02	Faint	Trembling NE-SW	C. E. McManigal.
	4 01?	Indio	33 43	116 13	3	1		Faint	Rumbling; gradual rocking	Fred N. Johnson.
	4 00?	Mecca	33 34	116 05	3	1	15		Gradual trembling	Edgar A. Palmer.
	4 15?	Mesa Grande	33 10	116 46	3	1		Faint	Very slight jar N-S	Edward H. Davis.
12	12 30	Lakeport	39 03	122 56	3	1	02	None	Gradual trembling N-S	Mrs. Elizabeth Lawlor.
14	12 05	Calexico	32 41	115 30	5	1	06	Loud	Severe lurch N-S accompanied by a heavy muffled explosion, and followed by loud rumbling and trembling.	H. M. Rouse.
		ILLINOIS.								
16	2 30?	Anna	37 28	89 14			15	None	Trembling W-E	Dr. James I. Hale.
	2 15?	Cairo	37 00	89 10	2	1	01	None	Gradual trembling NE-SW	R. T. Lindley.
		MICHIGAN.								
1	6 38	Calumet	47 14	88 28	3	1	01	None	Trembling	E. S. Gulison.
		TENNESSEE.								
4	9 21	Memphis	35 09	90 03	2	1	05		Bump	S. C. Emery.
16	2 15?	Clarksville	36 31	87 22	2	1	1? 00	Rumbling	Gradual trembling	R. L. Miller.
	2 15?	Memphis	35 09	90 03	5	2	02	Rumbling	Rocking N-S	S. C. Emery.
	2 30?	Savannah	35 12	88 15	5	2			Gradual rocking E-W	F. H. Kendall.
	2 ?	Union City	36 26	89 04	3	1	02	None	Rocking N-S	J. R. Oliver.
		PORTO RICO.								
11-29	14 15	Aguadilla	18 26	67 09	10	55+	*20 ..	None	Began with trembling, followed by rocking and bumping NE-SW; buildings thrown down. A tidal wave swept inland over an area 2 miles long and a half mile wide, leaving its marks 40 feet high on the cliffs. Thirty houses and 9 lives were lost in this tidal wave. First shock lasted 2½ minutes, all others from 1 to 5 or 6 seconds and with intensities 2-7.	William M. Orr.
		Isabela	18 30	67 03	10	55+	*20 ..	None	Began with trembling followed by rocking and bumping NE-SW; buildings thrown down, but no one hurt. Tidal wave swept away several houses. There were almost continuous tremors after the first shocks, intensifying at intervals for several days, and many slight shocks and tremors each day continuing till Oct. 29. Slight shocks were still continuing at intervals into November.	Do.
		San Juan	18 29	66 07	8	6	12 ..	None	First shock was vertical or bumping for 2 minutes; remainder were rocking or swaying N-S. Second shock lasted a half minute; last four only a few seconds each.	F. E. Hartwell.
26	3 40	San Juan	18 29	66 07	7	1	20	None	Vertical bump and trembling E-W	Do.

* Days.

TABLE 2.—*Instrumental reports, October, 1918.*

(Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.)

[For significance of symbols see REVIEW for January, 1918, p. 34.]

Alabama. *Mobile. Spring Hill College.* Cyril Ruhlmann, S. J.

Lat., 30° 41′ 44″ N.; long., 88° 08′ 46″ W. Elevation, 60 meters.

Instrument: Wiechert 80 kg. horizontal.

Instrumental constants.. V — T_0 — ϵ —

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Oct. 11		iP	16 20 43	4			2,750	E-W component always undamped.
		S	16 25 07	12				
		L_N?	16 26 07	8				
		L_E?	16 27 23	8				
		M_E	16 31 02	15	*36,000			
		M_N	16 31 19	15		*44,000		
		F	18 13 ..					
11		eP	18 09 47					
		S?	19 14 00					
		M_N	19 22 21	13		*1,500		
		F	19 27 ..					
19		P_E?	5 28 55					
		iP_N	5 29 00					
		S_E	5 31 59					
		S_N	5 32 12					
		M_N	5 33 05	6		*4,000		
		M_E	5 33 47	6	*12,000			
		F	6 47 ..					
25		eP	6 48 05				2,490	
		S	6 52 09					
		L_E	6 54 01					
		M_E	6 56 13	10	*3,000			
		M_N	6 56 13	8		*2,500		
		F	7 14 ..					

*Trace amplitude.

Alaska. *Sitka. Magnetic Observatory.* U. S. Coast and Geodetic Survey. F. P. Ulrich.

Lat., 57° 03′ 00″ N.; long., 135° 30′ 06″ W. Elevation, 15.2 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants.. $\begin{cases} E & V=10 & T_0=17 \\ N & V=10 & T_0=15 \end{cases}$

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Oct. 11		P_E	14 25 14					
		eS_N	14 33 40					
		eL_N	14 47 31	17				
		eL_E	14 49 ..	20				
		M_N	14 50 21	15		610		
		M_E	14 55 07	13	420			
		C_N	14 54 ..	13				
		C_E	14 58 ..	13				
		F_E	15 43 ..	12				
		F_N	15 56 ..	12				

Arizona. *Tucson. Magnetic Observatory.* U. S. Coast and Geodetic Survey. William H. Cullum.

Lat., 32° 14′ 48″ N., long., 110° 50′ 06″ W. Elevation, 769.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants.. $\begin{cases} E & V=10 & T_0=14 \\ N & V=10 & T_0=18 \end{cases}$

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Oct. 11		P_E	14 22 22					
		P_N	14 22 26					
		S_E	14 28 47					
		S_E	14 28 52					
		eL_N	14 34 15					
		M_N	14 42 30	12		480		
		M_E	14 48 12	12	440			
		C_N	14 47 ..	12				
		C_E	14 51 ..	12				
		F_N	15 30 ..	13				
		F_E	16 03 ..	12				

Arizona. *Tucson. Magnetic Observatory*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Oct. 14		e_E	12 37 15	22				Nothing definite on N.
		M_E	12 41 ..	20	10			
		F_E	12 47 ..					
19		e_E	2 07 13					
		eL_E	2 07 54					
		e_N	2 08 44					
		M_E	2 09 ..	9	10			
		eL_N	2 10 00					
		M_N	2 13 ..	9		10		
		F_N	2 17 ..	8				
		F_E	2 24 ..	9				
19		eP_N	3 28 40	4				Phases not well defined.
		eP_E	3 28 47	4				
		S_N	3 33 09	4				
		S_E	3 33 31					
		L_N	3 38 51					
		L_E	3 38 59					
		M_N	3 40 19	19		140		
		M_E	3 40 47	19	120			
		F_N	3 47 ..	15				
		F_E	3 51 ..	14				
25		eP_N	3 52 34					No well defined phases.
		eP_E	3 52 49					
		eL_E	4 06 ..	24				
		eL_N	4 07 ..					
		M_N	4 13 30	15		5		
		M_E	4 18 10	14	10			
		F_N	4 20 ..					
		F_E	4 21 ..					
27		eL_E	16 10 30	25				Nothing on N.
		M_E	16 14 30	21				
		F_E	16 31 ..	18				
27		eL_E	18 00 50	20				Nothing on N.
		M_E	18 14 45	17	10			
		F_E	18 26 ..	17				

California. *Berkley. University of California.*

Lat., 37° 52′ 16″ N.; long., 122° 15′ 37″ W. Elevation, 85.4 meters.

(*See* Bulletin of the Seismographic Stations, University of California.)

California. *Mount Hamilton. Lick Observatory.*

Lat., 37° 20′ 24″ N.; long., 121° 38′ 34″ W. Elevation, 1,281.7 meters.

(*See* Bulletin of the Seismographic Stations, University of Califronia.)

California. *Point Loma. Raja Yoga College.* F. J. Dick.

Lat., 32° 43′ 03″ N.; long., 117° 15′ 10″ W. Elevation, 91.4 meters.

Instrument: Two-component, C. D. West seismoscope.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Oct. 18					50	100		Tremors during 24 hours preceding 15h.

California. *Santa Clara. University of Santa Clara.* J. S. Ricard, S. J.

Lat., 37° 26′ 36″ N.; long., 121° 57′ 63″ W. Elevation, 27.43 meters.

(*See* Record of the Seismographic Station, University of Santa Clara.)

TABLE 2.—*Instrumental reports, October, 1918*—Continued.

Colorado. *Denver. Sacred Heart College.* Earthquake Station. A. W. Forstall, S. J.

Lat., 39° 40′ 36″ N.; long., 104° 56′ 54″ W. Elevation, 1,655 meters.

Instrument: Wiechert 80-kg., astatic, horizontal pendulum.

Instrumental constants..........

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Oct. 2		P	14 22 ..					S not discernible. Record affected by heavy machinery in motion.
		S	14 ? ?					
		L_E	14 33 ..	15-20	*4,000			
		L_N	14 34 ..	20		*4,000		
		M_N	14 37 ..	15		*8,000		
		M_E	14 41 ..	15	*7,500			
		C	15 07 ..					
		F_N	15 29 ..					
		F_E	15 31 ..					
12-13								Activity on both compoments at intervals during day.
16								Wavelets at intervals during day.
25		L_E	17 12 ..					Visible waves and thickening of pen marks.
		F_E	17 17 ..					
28		L	1 10 ..					Visible activity on both components.
		F	2 30 ..					

* Trace amplitude.

District of Columbia. *Washington. U. S. Weather Bureau.*

Lat., 38° 54′ 12″ N.; long., 77° 03′ 03″ W. Elevation, 21 meters.

Instrument: Marvin (vertical pendulum), undamped. Mechanical registration.

Instrumental constants.. V 110 T_0 6.4

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Oct. 4		P	9 27 04					Disturbance small and irregular. Apparently a near-by 'quake.
		F	9 29 ..					
11		P	14 19 27				2,460	F lost in next 'quake.
		S	14 23 29					
		M_E	14 24 20		*40,000			
		L	14 24 50					
		M	14 30 30		*35,000	*50,000		
		F	17 ? ?					
11		P	17 08 41				2,450	F lost in microseisms.
		S	17 12 42					
		L	17 14 06	16				
		F	18 ? ?					
11		P	20 11 18					Do.
		F	20 20 ?					
12		P	0 04 38				2,460	Do.
		S?	0 08 40					
		F	0 15 ..					
12		P	0 20 50				2,460	Do.
		S	0 24 52					
		L	0 30 30	12				
		F	0 ? ?					
12		P?	0 37 58					Do.
		S?	0 41 54					
		F	0 ? ?					
12		P	8 24 40				2,440	
		S	8 28 40					
		L	8 34 15	14				
		F	9					
13		P	4 56 32				2,460	
		S	5 00 34					
		L	5 06 ..	12				
		F	5 30 ..					
14		P	0 29 31				2,480	
		S	0 33 35					
		L	0 38 50	12				
		F	1 15 ..					

* Trace amplitude.

District of Columbia. *Washington. U. S. Weather Bureau*—Contd.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Oct. 14		P	2 20 30				2,500	
		S	2 24 35					
		L	2 30 ..	12				
		F	2 40 ..					
18		P	21 38 32				2,440	
		S	21 42 32					
		L	21 46 ..	20				
		F	22					
19		L	2 18 to					
			2 28 ..					
19		P	3 28 45				3,070	
		S	3 33 33					
		L	3 39 30	16				
		F	4 30 ..					
25		P	3 47 56				2,410	
		S	3 51 54					
		L	3 53 15					
		L	3 57 ..	16				
		F	5					
27		eL	16 31 ..	24				
		F	16 50 ..					
27		e	17 29? ..					Time uncertain. Clock failed to register hour marks.
		S?	17 32?27					
		eL	18 10? ..					
		L	18 25? ..	20				
		L	18 33? ..	16				
		F	19					
29		P	12 31 22				2,020	
		S	12 34 47					
		L	12 42 ..	20				
		F	13 15 ..					

District of Columbia. *Washington. Georgetown University.* F. A. Tondorf, S. J.

Lat., 38° 54′ 25″ N.: long. 77° 04′ 24″ W. Elevation, 42.4 meters. Subsoil: Decayed diorite.

Instruments: Wiechert 200 kg. astatic horizontal pendulums, 80 kg. vertical.

Instrumental constants.	V	T_0	ϵ
E	165	5.4	0
N	143	5.2	0
Z	*80*	*3.0*	*0*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Oct. 4		e	9 27 03					Heavy microseisms.
		eL?	9 29 24					
		F	9 50 ..					
11		iP	14 19 19					Gram from Mainka. F lost in a second quake. Vertical lost in changing sheets.
		S_E	14 23 28					
		iS_N	14 23 34					
		eL	14 24 38					
		M_N	14 30 19	14		*10,500		
		M_{E1}	14 30 27	9	*38,000			
		M_{E2}	14 35 50	12	*19,000			
		M_{E3}	14 48 49	12	* 6,500			
		M_{E4}	14 51 25	12	*7,000			
		M_{E5}	15 00 03		*13,000			
11		P_N	17 08 39					No distinct M.
		P_E	17 08 41					
		iS_E	17 12 43					
		S_N	17 12 51					
		eL	17 14 00					
		L_N	17 17 03	16				
		L_E	17 18 31	15				
		F	18 10 ..					
		VERTICAL.			Az.			
		P	*17 08 43*					Do.
		S	*17 12 34*					
		eL	*17 15 48*					
		L	*17 16 14*	15				
		F	*18 20 ..*					
12		eP_E	0 20 42					
		eP_N	0 20 48					
		S?	0 25 27					
		L	0 35 47	9				
		F	0 50 ..					
12		L	1 45 17	7				
		to	1 50 ..					

* Trace amplitude.

TABLE 2.—*Instrumental reports, October, 1918*—Continued.

District of Columbia. *Washington. Georgetown University*—Contd.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Oct. 12		P_N	8 24 39					Microseisms. No distinct M.
		P_E	8 24 44					
		S_N	8 28 41					
		S_E	8 28 52					
		L	8 34 22	12				
		F	9 09 ..					
13		eP	4 56 34					No distinct M.
		S?	5 00 37?					
		eL	5 02 37?					
		L_E	5 05 28	17				
		L_N	5 06 35	11				
		F	5 16 ..					
13		L	22 24 to	7				Heavy microseisms.
			22 30 ..					
14		iP_N	0 29 33					No distinct M.
		iP_E	0 29 35					
		iS_E	0 33 40					
		eS_N	0 33 42					
		eL	0 34 47					
		L_E	0 39 01	13				
		L_N	0 39 22	17				
		F	1 03 ..					
14		L_N	2 30 27	11				Does not show on E.
		to	2 35 ..					
18		eP_N	21 38 35					
		eP_E	21 38 44					
		S_N	21 42 49					
		S_E	21 42 58					
		eL?	21 44 06					
		L_N	21 48 08	15				
		L_E	21 48 38	16				
		F	22					
19		L	2 18 to					Scarcely shows on E. Microseisms.
			2 24 ..	18				
19		eP	3 28 48					Microseisms.
		S	3 33 34					
		eL_E?	3 35 34					
		M_E	3 38 35	19	*800			
		M_N	3 ? ?	11		*400		
		F	4 22 ..					
25		P_E	3 47 58					Microseisms. No distinct M.
		iP_N	3 47 58					
		S_N	3 52 09					
		S_E	3 52 16					
		eL_E	3 53 42					
		eL_N	3 53 48					
		L_E	3 55 27	10				
		L_N	3 57 16	16				
		F	5 20 ..					
27		e	16 01 20					
		L_E	16 26 20	30				
		L_N	16 28 20	30				
		F	17					
27		e	17 27 36					Heavy microseisms. Very difficult.
		S?	17 32 22					
		F	19 25 ..					
29								'Quake registered. Data omitted because of uncertainty of time. Clock out of order.
30		e	12 43 ?					Sheet off at 13h., .08m. Time doubtful. Clock out of order.
		F	? ? ?					

* Trace amplitude.

Hawaii. *Honolulu. Magnetic Observatory.* U. S. Coast and Geodetic Survey. Frank Neuman.

Lat., 21° 19′ 12″ N.; long., 158° 03′ 48″ W. Elevation, 15.2 meters.

Instrument: Milne seismograph of the Seismological Committee of the British Association.

Instrumental constant.. T_0 18.5

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.								
Oct. 1		e	1 22 00					Phase ill-defined.
		L	1 23 18					
		M	1 32 48	18	*300			
		C	1 37 ..	18				
		F	2 47 ..	18				

* Trace amplitude.

Hawaii. *Honolulu. Magnetic Observatory*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1818.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Oct. 2		eP	0 31 48					
		S	0 38 42	18				
		L	0 45 54	18				
		M	0 56 30	19	*100			
		C	1 02 ..	19				
		F	1 34 ..	19				
6		e	20 21 00	18				
		L	20 31 00					
		M	20 34 00	17				
		F	20 44 ..	17				
9		iP	9 40 48	17				
		eL	10 02 30					
		M	10 05 00	18	*300			
		C	10 10 ..	18				
		F	10 41 ..	19				
11		P	14 27 24	17				
		S	14 37 42	19	*2,100			
		L	14 55 00	21				
		M	15 09 18	17	*3,100			
		C	15 46 ..	17				
		F	18 30 ..	17				
13		P	12 57 48					
		S	13 00 54					
		L	13 02 00					
		M	13 07 00	18	*200			
		C	13 10 ..	18				
		F	13 42 ..					
14		P	12 15 18					Waves ill-defined, because of irregular motion of the paper.
		S	12 19 12					
		L	12 22 ..					
		M	12 26 30	18	*500			
		F	13 33 ..	19				
16		e	20 27 30					Phases ill-defined, because of irregular motion of the paper.
		L	20 46 ..					
		M	20 53 48	16	*100			
		C	21 04 ..	17				
		F	22 20 ..					
19		P	3 34 06	19				An abrupt change at 3h 53m 12s, too early for L.
		S	3 42 48	19				
		L	3 55 ..					
		M	3 57 42	18	*1,000			
		C	4 04 ..	18				
		F	5 41 ..	18				
21		eL	23 09 ..					
		M	23 15 ..	18	*100			
		F	23 28 ..					
22		eL	9 48 12					
		M	9 53 06	18	*100			
		F	9 57 ..					
22		P	10 28 24	18				
		L	10 40 ..					
		M	10 45 ..	19	*100			
		C	10 48 ..	18				
		F	11 14 ..	18				
24		eP	19 33 00					
		L	19 46 ..					
		M	19 51 00	18	*100			
		C	19 53 00	18				
		F	20 15 ..					
25		eP	3 55 00					
		iS	4 06 00	19				
		L	4 23 00					
		M	4 34 12	18	*300			
		C	4 40 ..	17				
		F	6 34 ..	17				
27		iP	15 37 00	17				Tremors continue to the beginning of the next quake.
		iS	15 43 42	17				
		L	15 51 06	27				
		M	15 58 30	19	*6,900			
		C	16 24 ..	19				
27		eP	17 19 18					Obscured by C of preceding quake.
		iS	17 24 42	18				
		eL	17 31 30					
		M	17 41 00	17	*2,400			
		C	18 09 00	18				
		F	20 14 ..	18				
29		eL	12 59 00					
		M	13 02 00	18	*100			
		F	13 19 ..					

* Trace amplitude.

TABLE 2.—*Instrumental reports, October, 1918*—Continued.

Kansas. *Lawrence. University of Kansas.* **Department of Physics and Astronomy. F. E. Kester.**

Lat., 38° 57′ 30″ N.; long., 95° 14′ 58″ W. Elevation, 301.1 meters.

Instrument: Wiechert.

Instrumental constants: E: V 177, T_0 3.4, ϵ 4:1; N: V 205, T_0 3.4, ϵ 4:1

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			H. m. s.	Sec.	μ	μ	Km.	
Oct. 4		eP_E	9 22 02					Disturbance identified by press reports from Pine Bluff and Little Rock, Ark.
		eP_N?	9 22 15					
		eS_E	9 22 51					
		L_N	9 23 16					
		L_E	9 23 17					
		M	9 23 22		10.2	7.8		
		F	9 30 ..					
11		iP_N	14 22 00					
		eP_E	14 22 01					
		iS_E	14 26 18					
		S_N?	14 27 14					
		L_E?	14 31 33					
		L_N?	14 31 43					
		M_N	14 33 29			39.8		
		M_E	14 37 13		35.0			
		F	16 03 ..					Records changed here.
19		eP_N	2 05 37					S not discernible. E phase not clear.
		L_N	2 09 46					
		M_E	2 12 50	15	1.7			
		M_N	2 18 04	6-8		0.5		
		F	2 33 ..					
19		P	3 28 24					S not discernible.
		to	3 28 26					
		L_E	3 32 46					
		L_N?	3 32 50					
		M_N	3 33 00			8.8		
		M_E	3 33 39		4.2			
		F	4 17 ..					

Maryland. *Cheltenham. Magnetic Observatory.* **U. S. Coast and Geodetic Survey. George Hartnell.**

Lat., 38° 41′ 00″ N.; long., 76° 50′ 30″ W. Elevation, 71.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: E: V 10, T_0 15; N: V 10, T_0 15

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918			H. m. s.	Sec.	μ	μ	Km.	
Oct. 4		P	9 27 29					
		eL_E	9 27 48					
		eL_N	9 28 00					
		M	9 28 06	3	10	20		
		F	9 29 ..					
11		P	14 19 29	4				Stylus passed off the edge of the paper twice in one direction on each component.
		S_E	14 23 38	13				
		S_N	14 23 45	13				
		eL_N	14 26 08	23				
		eL_E	14 27 28					
		M_E	14 30 13	15	4,700			
		M_N	14 30 33	15		5,200		
		C_E	14 35 ..	14				
		C_N	14 41 ..	13				
		F_E	15 38 ..	14				
		F_N	16 42 ..	14				
11		iP	17 08 40	3				No long waves on E.
		S_E	17 12 41	3				
		S_N	17 12 44	3				
		L_N	17 16 20					
		M_N	17 18 42	14	10	40		
		C	17 21 ..	13				
		F	17 51 ..	12				
12		i	8 24 43	3				No long waves on E.
		eL_N	8 34 19					
		M_N	8 34 50	13		10		
		F_N	8 41 ..					
13		P	4 57 ..	3				No long waves on E.
		eL_N	5 06 35					
		M_N	5 07 20	13				
		F	5 09 ..					
14		eP	0 30 26	3				No long waves on E.
		eL_N	0 39 30					
		M_N	0 40 17	12		10		
		F	0 50 ..					

Maryland. *Cheltenham. Magnetic Observatory*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			H. m. s.	Sec.	μ	μ	km.	
Oct. 18		P_N	21 38 41					Nothing on E.
		S_N	21 42 40	9				
		L_N	21 46 12					
		M_N	21 49 28	13		10		
		C_N	21 50 ..					
		F_N	21 52 ..					
19		eP_N	3 28 42	4				No long waves on E.
		eP_E	3 28 50	4				
		eS_N	3 33 27	4				
		L_N	3 39 01	18				
		M_N	3 42 18	12	30	150		
		C_N	3 44 ..	12				
		F_N	4 05 ..	12				
25		P	3 48 27	3				No long waves o E.
		S	3 52 28	3				
		eL_N	3 56 20	18				
		M_N	4 00 48	16		40		
		C_N	4 08 ..	16				
		F_N	4 37 ..	12				
27		eL_N	16 35 ..					Nothing on E.
		F_N	18 47 ..					
29		eP_N	12 33 55					Nothing on E. Time of P uncertain on account of microseisms.
		eL_N	12 41 57					
		M_N	12 44 00	16		10		
		C_N	12 49 ..	16				
		F_N	12 57 ..	14				

Massachusetts. *Cambridge. Harvard University Seismographic Station.* **J. B. Woodworth.**

Lat., 42° 22′ 36″ N.; long., 71° 06′ 59″ W. Elevation, 5.4 meters. Foundation: Glacial sand over clay.

Instruments: Two Bosch-Omori 100 kg. horizontal pendulums (mechanical registration).

Instrumental constants: E: V 80, T_0 23, ϵ 0; N: V 50, T_0 25, ϵ 4:1

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			H. m. s.	Sec.	μ	μ	km.	
Oct. 11		*O*	14 14 14				2,690	24° 10′. Destructive at west end of Porto Rico. Tidal wave at Aguadilla and San Juan. N stylus not registering from 14h. 24m. 52s. to 14h. 41m. 28s. E stylus left drum at 14h. 28m. 22s. and worked on and off during M. eL_E not readily distinguished from S waves. As read, velocity of long waves comes out 243.8 kms. per minute. PS_E alternating waves. F lost in next record.
		P_N	14 19 41	4				
		eP_E	14 20 11	4				
		PS_E	14 22 40	2				
		S_E	14 24 01	10				
		S_N	14 24 07					
		eL_E?	14 25 16	20				
		M_E	14 28 17					
		M_E	14 29 52	12		*41,500		
		M_E	14 42 ..	12				
		M_E	14 46 ..	12				
		M_E	14 49 ..	12				
		M_E	14 52 37	12				
		M_E	14 53 47	12				
		M_E	14 54 ..	12				
		M_E	14 55 ..	12				
		M_E	14 56 ..	12				
		$_N$	14 42 ..					
		F?	17 postea					
11		*O*	*17 04 48*				1,900	17° 6′.
		P_N	17 08 49					
		P_E	17 09 49	4				
		S_E	17 12 11					
		S_E	17 12 25	6				
		eL_N	17 13 08	15				
		e_E	17 13 39	8				
		eL_E	17 14 49	18				
		M_N	17 16 10	15		*11,000		M_E, 17h. 16m. 52s.; 1,000 micra.
		C_E	17 19 30					
		C_N	17 26 ..	12				
		F?	18					
12		*O*?	*0 14 23*				3,440?	30° 37′.
		P_N	0 20 59					
		S_E	0 26 12	6				
		L_N?	0 30 11	12				
		M_N	0 32 10	12				
		F?	0 43 ..					
12		L_N	1 46 21	10-11				
		F	1 48 ..					

* Trace amplitude.

TABLE 2.—*Instrumental reports, October, 1918*—Continued.

Massachusetts. *Cambridge. Howard University Seismographic Station*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Oct. 12	....	*O*	*8 19 31*				2,640	23° 45′.
		iP_N	8 24 53	3				
		eP_E	8 25 17	2				
		S_N	8 29 09	6				
		S_E	8 29 39	6				
		eL_E	8 31 00	20				
		L_N	8 32 16	15				
		L_N	8 35 31	13–14				
		F	8 52 ..					
13	....	*O*	*22 postea*					
		L_N	22 26 ..	8				
		F	22 27 ..					
14	....	*O*	*0 25 14*				2,150	19° 21′.
		eP_N	0 29 43					
		eP_E	0 29 56					
		S_E	0 33 19	6				
		S_N	0 33 54	10				
		eL_N	0 35 50	25				
		eL_E	0 36 58	20				
		M_E	0 40 47	12				E damped 1.5/1 by magnet.
		M_N	0 40 49	13		*7,000		Undamped.
		F_E	1 20 ..					
14	....	*O*	*2 postea*					
		L_N	2 30 37	10				
		F	2 32 18					
14	....	*O*	*12 02 41*				10,320	92° 59′ by S_E–P_E.
		O	*12 02 48*				10,240	92° 20′ by L_N–S_E. NW. India?
		eP_E	12 15 59					
		e_N	12 25 42					
		S_E	12 27 11					
		S_N	12 28 32					
		e_E	12 41 11					
		e_N	12 42 24					
		e_N	12 47 05	6				
		eL_N	12 50 44	30				
		eL_E	12 54 20	40				
		L_E	12 56 ..	35				
		M_E?	13 02 ..	20	*600			Trace.
		L_E	12 08 ..	15				
		F_E?	13 27 ..					
		L_E repl	14 15 48	16				Long waves returning from anticentrum, amplitudes very slight.
		to	14 22 41	20				
		F	14 28 45					
18	....	*O*	*21 30 13*				3,235	29° 19′. P lost in microseisms.
		S_N	21 41 30	6½				
		S_E	21 41 51	7				
		eL_E	21 44 22	25				
		eL_N	21 44 44					
		L_E	21 46 22	15				
		L_N	21 52 42	12				
		F	22 08 ..					
19	....	L_E	2 18 31	18				
		L	2 21 19	20				
		F	2 35 41					
19	....	*O*?	*3 22 07*				3,870?	△ from eL_E–P_N.
		P_N	3 29 16					
		P_E	3 30 20					
		S_N?	3 34 24					
		S_E?	3 35 10	11				
		eL_E	3 39 03	40				
		eL_N	3 39 07	34				
		M_N	3 44 30			*2	7,500	Undamped.
		M_E	3 44 34		*1,900			Damped 1½/1 magnetically.
		F_E	4 33					
*25	....	*O*	*3 42 59*				2,630	Similar to record of Oct. 11, 1918, *O*: 14h. 14m. 14s.
		P_E	3 48 20	3				
		iP_N	3 48 47	4				
		e_N	3 49 43	2–4				
		S_E	3 52 35	7				
		S_N	3 53 09	6				
		e_N?	3 53 17	12				
		L_E	3 53 44	20				
		eL_N	3 55 31					
		M_N	3 57 05			*4,250		Undamped.
		L_E	3 57 14	24				
		L_E	4 01 36	12	*500			Damped 1½/1.
		M_N	4 04 27					
		C_N	4 05 01					
		F_E	4 52					
27	....	*O*?	*15 33*				12,250?	110° 15′. P not identified among small microseisms. N gave a less definite record. F lost in next 'quake.
		S_E?	16 00 00	8				
		e_E	16 04 19	6				
		e_E	16 13 19	6				
		eL_E?	16 26 09					
		L_E	16 28 30	30				
		L_E	16 30 21	32				
		L_E	16 35 03	20				
		L_E	16 39 53	18				
		to	16 48 05					
		L_E	16 58 49	15				
		to	17 02 30					
		F	17 ? ?					

* Trace amplitude.

Massachusetts. *Cambridge. Howard University Seismographic Station*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Oct. 27	....	*O*	*17 postea*					Probably two 'quakes. See attempted diagnosis in two records next below. N less definite.
		e_E	17 22 53					
		e_E	17 27 23	4				
		S_E	17 28 15	6				
		eL_E	17 31 51	15–8				
		L_E	17 33 35	8				Sinusoidal waves set in.
		L_E	17 42 05	18				One wave.
		L_E	17 42 23	8				
		L_E	18 11 16	26				
		L_E	18 28 33	20				
		L_E	18 34 25	16				
		L_E	18 44 47	15				
		L_E	18 53 32	15				
		L_E	19 01 17	12				
		L_E	19 17 05	20				
		F?	19 50 15					
27	....	*O*	*17 12 16*				3,600	32° 24′. △ from L–S. F lost in next 'quake.
		eP_E	17 22 23					
		S_E	17 28 15	6				
		eL_E	17 31 51	15–8				
		L_E	17 33 35	8				
		to	17 42 05	18				
		L_E	17 42 23	8				
		to	17 48 15					
		F	? ? ?					
27	....	*O*	*17 22 36*				11,100	99° 54′. N record less definite.
		S_E	17 48 15					
		eL_E	18 11 16	26				
		L_E	18 28 33	20				
		L_E	18 34 25	16				
		L_E	18 39 55	20				
		L_E	18 44 47	15				
		L_E	18 53 32	15				
		L_E	19 01 17	12				
		L_E	19 17 05	20				
		F_E?	19 50 15					
30	....	*O*	*12 postea*				7,000?	P and S lost in microseisms of 6-second period.
		e_N	12 37 54	8				
		e_N	12 42 31	12				
		eL_N	12 43 28	28				
		eL_E	12 44 15	24				
		L_N	12 44 39	18				
		L_E	12 45 20	16				
		F_E	13 05					

* Trace amplitude.

Missouri. *Saint Louis. St. Louis University.* Geophysical Observatory. J. B. Goesse, S. J.

Lat., 38° 38′ 15″ N,; long., 90° 13′ 58″ W. Elevation, 160.4 meters. Foundation: 12 feet of tough clay over limestone of Mississippi system, about 300 feet thick.

Instrument: Wiechert 80 kg. astatic, horizontal pendulum.

Instrumental constants.. V 80, T_0 7, ϵ 5:1

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
4	....	iP	9 22 36				500	Pine Bluff, Ark.
		L	9 22 48	(?)		*1,000		
		F	9 24 12					
11	....	P_N	14 20 30				3,300	Porto Rico.
		P_E	14 20 ?					
		S_E	14 25 24					
		S_N	14 25 30					
		L_E	14 27 30					
		L_N	14 27 48					
		M_N	14 30 12	12		*22,000		
		M_N	14 31 30			*24,000		
		M_E	14 32 36	24	*10,000			
		F	16 10 ..					
11	....	iP_N	17 09 36				4,500	Hardly any record on E.
		S_N	17 16 00					
		L_N	17 20 36	12		*1,000		
		F	17 35 ..					
19	....	eP_N	3 28 18				2,800	
		P_E	3 ? ?					
		iS_N	3 32 48					
		S_E	3 33 30					
		L_N	3 34 36					
		M_N	3 40 12	24		*12,000		
		eL_E	3 40 42	12	*1,000			
		F	4 05 ..					
25	....	P_N	3 48 54				3,000	No record on E.
		S_N	3 53 42					
		L_N	3 56 06					
		M_N	4 03 00	3		*1,500		
		F	4 20 ..					

* T race amplitude.

TABLE 2.—*Instrumental reports, October, 1918*—Continued.

New York. *Buffalo. Canisius College.* John A. Curtin, S. J.

Lat., 42° 53′ 02″ N.; long., 78° 52′ 40″ W. Elevation, 190.5 meters.
Instrument: Wiechert 80 kg. horizontal.

Instrumental constants.. V 80, T_0 7, ϵ 5:1

(Report for October, 1918, not received.)

New York. *Fordham. Fordham University.* Daniel H. Sullivan, S. J.

Lat., 40° 51′ 47″ N.; long., 73° 53′ 08″ W. Elevation, 29.3 meters.
Instrument: Wiechert, 80 kg.

Instrumental constants..	V	T_0	ϵ
E	72	5.0	0
N	72	5.0	0

(Report for October, 1918, not received.)

New York. *Ithaca. Cornell University.* Heinrich Ries.

Lat., 42° 26′ 58″ N.; long. 76° 29′ 09″ W. Elevation, 242 meters.
Instruments: Two Bosch-Omori, 25 kg., horizontal pendulums (mechanical registration)

Instrumental constants..	V	T_0	ϵ
E	13	22	4:1
N	14	25	4:1

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			H. m. s.	Sec.	μ	μ	km.	
Oct. 4		e_N	9 27 52	2				
		L_N	9 28 23	8				
		F_N	9 32 ..					
11		P_N	14 19 59	3				
		i_N	14 20 51	7		*1700		
		S_N	14 24 32	15				
		M_N	14 29 13	14		*9000		
		M_E	14 32 37	13	*13000			
		M_E	14 33 30	13	*14000			
		M_N	14 33 35	12		*18000		
		M_N	14 34 40	12		*15000		
		F_N	17 03 ..					
11		P_N	17 09 08	3				
		S_N	17 13 39	7				
		L_N	17 15 35	20				
		F_N	18 00 ..					
14		P_N	0 30 05	3				
		S_N	0 34 31	6				
		eL_N	0 37 15	20				
		F_N	0 52 ..					
14		eP_N	8 25 03	3				
		eS_N	8 29 45	5				
		L_N	8 32 18	22				
		F_N	8 50 ..					
14		P_N?	12 16 22	4				P indistinct, possibly microseisms.
		e_E	12 19 07	4				
		eS_N	12 27 59	8				
		eS_E	12 28 38	9				
		eL_E	12 55 ..	25				
		F	13 09 ..					
18		eP_N	21 39 58	5				Early phases obscured by microseisms.
		eS_E	21 44 33	7				
		eS_N	21 44 40	6				
		L_E	21 46 32	22				
		F_E	22 12 ..					
19		e	2 16 30					Microseisms.
		eL_E	2 19 35	18				
		F_E	2 36 ..					
19		P_N	3 29 47	4				Do.
		S_E	3 35 20	5				
		S_N	3 35 21	5				
		F_E	4 33 ..					
25		P_N	3 48 43	5				
		S_N	3 53 11					
		S_E	3 53 12					
		L_E	3 55 04	23				
		F_E	5 17 ..					
27		e	15 48 30					F lost in next 'quake.
		e	15 54 30					
		e	15 57 15					
		e	16 04 ..					
		eL	16 25 ..	28				
		F	? ? ?					
27		e	17 36 ..					
		eL	18 04 30					
		F	19 28 ..					
29		e_N	12 37 20	4				
		e	12 41 ..					
		eL_E	12 43 30	18				
		F_E	13 11 ..					

* Trace amplitide.

Panama Canal. *Balboa Heights.* Governor, Panama Canal.

Lat., 8° 57′ 39″ N.; long., 79° 33′ 29″ W. Elevation, 27.6 meters.
Instruments: Two Bosch-Omori, 100 kg.

Instrumental constants.. V 35, T_0 20

(Report for October, 1918, not received.)

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			H. m. s.	Sec.	μ	μ	Km.	
Oct. 11		P_E	14 19 07				1,370	
		P_N	14 19 08					
		L_E	14 22 07					
		L_N	14 22 16					
		M_E	14 22 27		*22,000			
		M_N	14 22 30			*16,000		
		F_N	15 34 00					
		F_E	15 36 13					
11		P	17 09 00		*600	*500		Faint trace.
		F_E	17 20 00					
		F_N	17 28 00					
14		P	0 30 00					Faint trace. Amplitudes too small to measure.
		F	0 35 00					
19		P_E	3 26 46				1,325	
		P_N	3 26 54					
		L	3 30 46					
		M_N	3 31 06			*600		
		M_E	3 32 02		*700			
		F_N	3 43 00					
		F_E	3 44 00					
25		P	3 46 32				1,060	
		L_E	3 49 32					
		M_E	3 49 42		*1,100			
		L_N	3 49 44					
		M_N	3 49 56			*2,000		
		F_E	4 11 00					
		F_N	4 15 00					
29		P_N	12 26 53				1,110	
		P_E	12 26 54					
		L_E	12 29 26					
		M_E	12 29 50		*1,400			
		M_N	12 31 54			*1,100		
		F_E	12 43 16					
		F_N	12 45 00					

* Trace amplitude.

Porto Rico. *Vieques. Magnetic Observatory.* U. S. Coast and Geodetic Survey. Wallace M. Hill.

Lat., 18° 09′ N.; long., 65° 27′ W. Elevation, 19.8 meters.

Instruments: Two Bosch-Omori.

Instrumental constants..	V	T_0
E	10	17.5
N	10	18.2

(Report for October, 1918, not received.)

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			H. m. s.	Sec.	μ	μ	Km.	
Oct. 11		P	14 15 07					Within 15 seconds after beginning, pendulums swung against stops jarring the stylus points from their bearings. E was replaced at 14h 21m and N at 14h 24m.
		L_E	14 15 07					
		L_N	14 15 12					
		M						
		C	14 27 ..	15				
		F_N	16 18 ..	12				
		F_E	16 32 ..	12				
11		P_N	15 50 51	2				The large number of small shocks recorded during the rest of the month are of the same general character, beginning with waves of 1 to 2 seconds period and ending with waves of 4 to 6 seconds period. In a few cases there appear to be two or three long waves of 10 to 12 seconds period at the time of the maximum with the short-period waves superimposed upon them.
		P_E	15 50 54	2				
		L_N	15 51 20					
		M_N	15 51 34			60		
		M_E	15 51 54		40			
		F	15 56 ..	4				

TABLE 2.—*Instrumental reports, October, 1918*—Continued.

Porto Rico. *Vieques. Magnetic Observatory*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Oct. 11		P	16 02 28	2				
		L_N	16 02 51					
		L_E	16 02 58					
		M	16 03 08		170	180		
		F	16 10 ..	5				
11		P	17 04 17	6				
		eL_E	17 04 26	16				
		eL_N	17 04 36	18				
		M_N	17 05 13	18		3,240		
		M_E	17 06 38	14	1,250			
		C	17 07 ..	11				
		F	17 33 ..	8				
11		eP_E	17 18 28					
		eL_N	17 18 54					
		M_E	17 19 28		20	20		
		F	17 24 ..					
11		eP_E	17 24 20					
		eP_N	17 24 33					
		F	17 30 ..		20	20		
11		P	18 26 51					
		M_N	18 27 02		10	30		
		F	18 31 ..					
11		P	19 09 00					
		eL_N	19 10 03					
		eL_E	19 10 06					
		M	19 10 23		40	40		
		F	19 18 ..					
11		eP_E	20 06 53					
		eP_N	20 07 06					
		M_N	20 07 35			170		
		M_E	20 07 53		60			
		F	20 17 ..					
11		eP_E	21 51 47					
		eP_N	21 51 55		10	10		
		F	21 57 ..					
11		eP	23 32 13					
		F	23 39 ..		20	20		
11		eP	23 48 58					
		F	23 51 ..		10	10		
11		eP_N	23 58 42					
		eP_E	23 58 46					
		F	24 00 ..		10	20		
12		eP_E	0 00 00					
		eP_N	0 00 12					
		M_E	0 04 14		40	40		
		F	0 09 ..					
12		P_E	0 16 10					
		L	0 16 38					
		M_E	0 16 56		70	120		
		F	0 26 ..					
12		P_E	0 28 18					
		L_E	0 28 42					
		L_N	0 28 45					
		M_E	0 29 02		30	20		
		F	0 34 ..					
12		P_E	0 33 16					
		L_N	0 33 40		20	30		
		L_E	0 33 46					
		F	0 45 ..					
12		eP_E	1 03 14					
		eP_N	1 03 21					
		L_E	1 03 34					
		M_E	1 03 56		20	10		
		F	1 10 ..					
12		eP_E	4 31 43					
		eP_N	4 31 49					
		F	4 33 ..		10	10		
12		eP_E	4 33 43					
		L_E	4 34 07					
		L_N	4 34 12					
		M_E	4 34 43		20	20		
		F	4 44 ..					
12		eP	6 58 28					
		F	7 02 ..		20	20		
12		eP_E	8 09 42					
		L	8 10 03					
		M_E	8 10 24		20	20		
		F	8 14 ..					
Oct. 12		P_E	8 19 34	2				
		P_N	8 19 39	2				
		eL_E	8 19 52	16				
		eL_N	8 20 02	16				
		M_N	8 20 24	10		550		
		M_E	8 20 40	10	350			
		C	8 23 ..	8				
		F	8 41 ..	5				
13		eP_E	4 52 11					
		eP_N	4 52 19	2				
		eL_N	4 52 39	10				
		M_E	4 53 00		90			
		M_N	4 54 17	8		190		
		F	5 04 ..	4				
13		eP_N	18 19 38					
		eP_E	18 19 45					
		F	18 25 ..		10	20		
13		eP_N	20 23 47					
		eP_E	20 23 56					
		L_N	20 24 11					
		L_E	20 24 14					
		M_E	20 24 43		30			
		M_N	20 25 20			40		
		F	20 32 ..					
14		P	0 25 18	2				
		L_N	0 25 42					
		M	0 26 02	13	200	900		
		C	0 28 ..					
		F	0 40 ..	5				
14		P	2 16 21					
		L_E	2 16 42					
		L_N	2 16 48					
		M_E	2 17 04		20			
		M_N	2 18 00			20		
		F	2 24 ..					
14		P	4 53 26	1				Possibly two or three separate shocks.
		eL	4 53 48					
		F	5 03 ..	4	40	30		
15		eP_E	0 13 54	2				
		L	0 14 14					
		F	0 24 ..	5	20	20		
15		e_N?	3 15 46					
		e_E?	3 16 02					
		P?	3 16 14	2				
		eL_N	3 16 26					
		eL_E	3 16 36					
		M_E	3 16 55	10	70			
		M_N	3 17 25	8		70		
		F	3 29 ..	5				
16		eP_E	19 20 17	2				
		eP_N	19 20 25	2				
		L_N	19 20 46					
		F	19 31 ..	5	20	20		
17		e	8 19 40	2				
		L	8 19 59					
		M_E	8 20 16	10	40			
		M_N	8 20 44	14		40		
		F	8 26 ..					
17		eP_N	21 29 29					
		eP_E	21 29 35					
		F	21 36 ..		20	20		
18		P	19 22 54	2				
		L_N	19 23 19					
		F	19 29 ..	5	20	20		
18		P_E	21 34 13	2				
		P_N	21 34 17	2				
		L_N	21 34 35	17				
		L_E	21 34 42					
		M_E	21 35 00	18	620			
		M_N	21 35 51	11		370		
		C	21 37 ..	9				
		F	21 58 ..	7				
19		e_N	3 28 12					Distant arthquake.
		e_E	3 28 59					
		L	3 35 28	28				
		M_E	3 40 00	18	30			
		M_N	3 37 13	22		20		
		C_E	3 42 ..	15				
		C_N	3 39 ..	20				
		F	3 56 ..	14				

TABLE 2.—*Instrumental reports, October ,1918*—Continued.

Porto Rico. *Vieques. Magnetic Observatory*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	*μ*	*μ*	*km.*	
Oct. 19		eP_N	7 05 48	1				
		eP_E	7 05 57	1				
		eL_N	7 06 24					
		eL_E	7 06 37					
		M_E	7 06 41	5	30			
		M_N	7 07 14	5		20		
		F	7 14 ..	5				
21		eP	6 44 49					
		F	6 49 ..		20	20		
21		eP	6 49 12					
		F	6 55 ..		10	10		
21		eP_N	13 09 ..					Nothing definite on E.
		F_N	13 11 ..			10		
23		eP	14 31 10					
		F	14 38 ..		10	10		
24		eP	22 59 38					
		F	23 04 ..		10	10		
25		eP_N	3 43 26	2				N stylus jarred from bearings at 3 42 50; replaced at 3 53.
		L	3 43 29					
		M_E	3 44 05	17	7,000			
		C_E	3 48 ..	14				
		F_N	4 38 ..	10				
		F_E	4 55 ..	10				

Vermont. *Northfield. U. S. Weather Bureau.* **Wm. A. Shaw.**

Lat., 44° 10′ N.; long., 72° 41′ W. Elevation, 256 meters.

Instruments: Two Bosch-Omori, mechanical registration.

Instrumental constants.. $\begin{matrix} & V & T_0 \\ E & 10 & 15 \\ N & 10 & 16 \end{matrix}$

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	*μ*	*μ*	*km.*	
Oct. 11		P	14 20 19				2,870	
		S	14 24 53					
		L	14 26 53	18				
		M_N	14 33 ..			*25,000		
		M_E	14 34 30		*21,000			
		F	16 45 ..					
11		P_E	17 14 ..					Not conspicuous on N.
		eL_E	17 16 ..					
		F	17 30 ..					
19		e	3 30 50					
		L	3 43 30					
		F	4					
25		P	3 48 20				3,050	
		S	3 53 07					
		L	3 55 ..					
		L	3 58 ..					
		F	4 20 ..					

*Trace amplitude.

Canada. *Ottawa. Dominion Astronomical Observatory.* Earthquake Station. Otto Klotz.

Lat., 45° 23′ 38″ N.; long., 75° 42′ 57″ W. Elevation, 83 meters.

Instruments: Two Bosch photographic horizontal pendulums, one Spindler & Hoyer, 80kg. vertical seismograph.

Instrumental constants.. V 120 T_0 26

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	*μ*	*μ*	*km.*	
Oct. 1		e	0 16 45					Small irregular amplitudes in L.
		e	0 35 41					
		eL	0 41 ..					
		F	1 10 ..					
11		*O*	*14 14 10*				3,190	Porto Rico. F merged in next 'quake.
		P_N	14 20 24					
		S_N	14 25 21					
		L_N	14 28 ..					
		M_N	14 34 ..	12		550		
		L_N	14 55 ..	12				
		L_N	15 10 ..	10				
		L_N	15 30 ..	13				
		L_N	15 40 ..	13				
		L_N	15 50 ..	12				
		L_N	16 00 ..	12				
		L_N	16 15 ..	12				
		F	17 ? ?					

Canada. *Ottawa. Dominion Astronomical Observatory*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_P	Amplitude. A_Q	Distance	Remarks.
			H. m. s.	*Sec.*	*μ*	*μ*	*km.*	
			VERTICAL.		*Az.*			
1918. Oct. 11		*eP*	*14 20 38*					
		eS	*14 26 00*					
		eL	*14 29 ..*	*20*				
		L	*14 34 ..*	*12*				
		L	*15 00 ..*	*10*				
		F	*15 20 ..*					
			SASKATOON.					
		O	*14 14 44*				4,980	
		P	14 23 11					
		S	14 29 52					
		S_{repl}	14 33 10					
		L ?	14 37 ..					
			HALIFAX.					
		O	*14 14 10*				3,0^{8}0	
		P_N	14 20 14					
		S_N	14 25 03					
		L_N	14 28 ..					
11		e_E	17 08 15					The deformation instrument confirms the phases noted, and also seems to indicate phases at about 16h. 58m. and 17h. 03m. 30s. The record is so contradictory in itself and in conjunction with the Halifax and Saskatoon records next below that it is impossible to deduce a value for either Δ or *O*.
		e	17 09 34					
		i_E	17 14 15					
		eL	17 16 ..	18				
		F	18 20 ..					
			HALIFAX.					
		i_N	17 09 25					
		e	17 14 14					
		eL_E	17 15 30	18				
		eL_N	17 17 ..	16				
			SASKATOON.					
		i	17 12 22					
		i	17 24 31					
		eL	17 29 ..	16				
12		e_N?	0 25 ..					
		e	0 29 36					
		L	0 37 ..					
		F	0 50 ..					
12		e ?	8 30 ..					Irregular small amplitudes from 8h. 40m. to 9h. 10m.
		e	8 32 06					
		eL	8 34 48	14				
		F	9 10 ..					
14		P	0 30 ?					Disturbance lasting about an hour and of small amplitude. Minute breaks failed to record. Time approximated from deformation instrument whose rate is only 17mm. per hour.
		eL	0 36 ?	20				
		F	1 ?					
14		e	12 20?					Do.
		eL	12 28?					
		F	13 ?					
15		e_N	23 48 ..	3				
		e_N	23 50 12	4				
		eL	23 52 ..	12				
16		F	0 05 ..					
18		*O?*	*21 33 47*				2,890	
		eP_N?	21 39 33					
		eS?	21 44 08					
		eL	21 48 ..					
		L	21 50 ..	18				
		L	22 18 ..	12				
		F	22 25 ..					
19		e	2 13 30					
		eL	2 20 00	15				
		L	2 25 ..	8				
		F	2 50 ..					
19		*O*	*3 22 49*				3,620	
		iP	3 29 39					
		iS	3 33 04					
		eL	3 38 18					
		L	3 44 ..	18				
		L	4 03 ..	12				
		L	4 11 ..	12				
		F	4 30 ..					
			VERTICAL.		*Az.*			
		eL?	*3 39 ..*					
		L	*3 44 ..*	*20*				
		F	*3 45 ..*					

TABLE 2.—*Instrumental reports, October, 1918*—Continued

Canada. *Ontario. Dominion Astronomical Observatory*—Continued.

Date	Character.	Phase.	Time.	Period	Amplitude. A_P	Amplitude. A_Q	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Oct. 25		*O*	*3 42 50*				3,040	Reported from Porto Rico.
		P_N	3 48 50					
		eS_N	3 53 36					
		e	3 54 40	3				
		eL	3 55 ..	20				
		L	4 03 ..	12				
		L	4 14 ..	11				
		L	4 30 ..	11				
		F	5 05 ..					
27		*O*	*15 35 +*				13,000	△ from $S-P_{repl}$, and *O* from $S-I_s$ (interval S for S-O).
		eP_{repl}	15 55 23					
		eS	16 03 43					
		eL	16 29 ..	20				Sinusoidal L waves.
		L	16 43 ..	16				F lost in next 'quake.
		F	17 ? ?					
27		*O*	*17 06?* ..				13,500	Data very conflicting. △ probably too small and *O* too late.
		e	17 27 21					
		e	17 37 11					
		eL	18 05 54	26				
		L	18 30 ..	16				
		L	18 40 ..	16				
		L_{repl}?	19 04 ..	20				
		F	19 40 ..					
20		e_N	12 33 41	6				Microseisms mask the earlier phases. N component better of the two.
		e_N	12 37 00	6				
		e_N	12 38 56	6				
		e	12 40 26					
		e_N	12 43 ..					
		eL	12 46 ..	20				
		L	12 55 ..	12				
		L	13 06 ..	8				
		F	13 20 ..					

Canada. *Toronto. Dominion Meteorological Service.*

Lat., 43° 40′ 01″ N.; long., 79° 23′ 54″ W. Elevation, 113.7 meters. Subsoil: Sand and clay.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. $\overset{To}{18}$. Pillar deviation, 1 mm. swing of boom=0.50″.

Date	Character.	Phase.	Time.	Period	Amplitude. A_P	Amplitude. A_Q	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Oct. 1		eL	1 38 24					
		eL	1 42 00					
		M	1 45 06		*200			
		F	2 10 06					
2		L?	1 37 06?		*50			Phases masked by microseisms.
11		P	14 20 42				2,990	Porto Rico. Destructive tidal wave. Clear record.
		iP	14 21 12					
		iS	14 25 24					
		L	14 26 12					
		iL	14 29 48					
		M	14 34 36					
		to	14 36 36		(1)			
		eL	17 17 30					
		eL	17 20 06					
		M	17 25 06					
		F	18 02 00?					
13		M	3 00 24		*50			
13		eL	5 08 18					Marked gradual thickening.
		M	5 10 36		200			
		F	5 15 30					
13		L	13 52 24		*50			
		F	14 00 36					
14		L	0 34 30					
		eL	0 40 12					
		M	0 41 18		*300			
		F	1 16 54?					
14		e	12 28 18?					
		L	12 54 24					
		eL	12 56 24					
		M	13 00 54		*800			
		F	13 48 42					
15		L	23 49 00					F lost in microseisms.
		M	23 50 54		*100			
		F	? ? ?					

* Trace amplitude. [1] Over *25000.

Canada. *Toronto. Dominion Meteorological Service*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_P	Amplitude. A_Q	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	η	*km.*	
Oct. 18		S?	21 44 30					
		L?	21 46 24					
		eL	21 49 30					
		M	21 53 30		*600			
		F	22 06 30					
19		eL	2 18 48					
		M	2 20 06		*200			
		F	2					
19		P	3 28 42				3,910	Possibly Central Africa. F lost in microseisms.
		S	3 34 24					
		iL	3 41 06					
		iL	3 43 18					
		M	3 49 24		*1300			
		F						
25		eP	3 49 18				3,070	Reported from Porto Rico. Amlitude of P increased gradually.
		eS	3 54 06					
		eL	3 55 30					
		eL	3 59 48					
		M	4 03 36		*3000			
		iL	4 06 00					
		F	5 22 42					
27		e	15 29 48					Microseisms at 15h. 22m. Light off at 17h. 27m. attending to instrument. F merged into next 'quake.
		e	15 50 18					
		P?	15 56 18					
		e	16 09 18					
		L	16 24 48					
		L	16 26 30					
		eL	16 28 48					
		M	16 38 48		*1800			
		L	16 54 00					
		F	17 ? ?					
27		L	17 55 18					F merged in next 'quake.
		L	18 01 12					
		eL	18 17 48					
		L	18 22 36					
		M	18 28 54		*1500			
		eL	18 42 06					
		L	19 01 42					
		F	19 ? ?					
27		eL	19 14 42					
		M	19 26 18		*1400			
		F?	20 18 12					
29		L	12 43 48					
		M	12 47 00		*200			
		F	13 19 48					

* Trace amplitude.

Canada. *Victoria, B. C. Dominion Meteorological Service.*

Lat., 48° 24′ N.; long., 123° 19′ W. Elevation 67.7 meters. Subsoil: Rock.

Instrument: Wiechert, vertical; Milne horizontal pendulum, North. In the meridian.

Instrument constant.. $\overset{T_0}{18}$. Pillar deviation, 1 mm., swing of boom=0.54″.

Date	Character.	Phase.	Time.	Period	Amplitude. A_P	Amplitude. A_Q	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Oct. 1		L	1 19 47					
		M	1 26 11		*200			
		F	1 37 59					
2		Por L.	0 45 24?					
		M	1 21 48		*100			
		F	? ? ?					
9		M	9 46 34		*100			
		F	9 56 53					
11		P	14 23 38				5,750	Porto Rico. Disastrous 'quake.
		S	14 31 01					
		L	14 42 49					
		M	14 51 10		*9,000			
		M_{repl}	17 30 31					
		F	18 14 47					
			Vertical.			*Az.*		
		P	*14 24 00*	*6*			*6,110*	*Porto Rico.*
		S	*14 31 42*	*8-10*				
		L	*14 44 42*	*24*				
		M	*14 50 24*	*12*		*31*		
		F	.. .. ..					
13		P	2 57 49					
		L	3 01 16					
		M	3 02 15		*200			
		F	3 08 39					

* Trace amplitude.

TABLE 2.—*Instrumental reports, October, 1918*—Continued.

Canada. *Victoria, B. C.* *Dominion Meteorological Service*—Contd.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	*μ*	*μ*	*km.*	
Oct. 13	....	M.....	13 25 57	....	*100	....	......	
		F.....	13 39 43	....	....	....	......	
14	....	M.....	1 02 24	....	*100	....	......	
		F.....	1 20 06	....	....	....	......	
14	....	P.....	12 33 53	....	....	....	......	
		L.....	12 38 58	....	....	....	......	
		M.....	12 44 13	....	*500	....	......	
		F.....	13 40 07	....	....	....	......	
15	....	P.....	23 31 19	....	....	....	......	
		L.....	23 32 49	....	....	....	......	
		M.....	23 33 48	....	*200	....	......	
		F.....	23 42 14	....	....	....	......	
18	....	L.....	22 01 49	....	....	....	......	
		L.....	22 06 46	....	....	....	......	
		M.....	22 10 15	....	*200	....	......	
		F.....	22 15 02	....	....	....	......	
19	....	P.....	3 30 21	....	....	....	5,750	May be West Indies or Central America.
		S.....	3 37 44	....	....	....	......	
		L.....	3 46 35	....	....	....	......	
		M.....	3 54 27	....	*2,000	....	......	
		F.....	4 49 02	....	....	....	......	
25	....	P.....	3 52 18	....	....	....	6,130	
		S.....	4 00 01	....	....	....	......	
		L.....	4 11 30	....	....	....	......	
		M.....	4 19 32	....	*9,000	....	......	
		F.....	5 11 30	....	....	....	......	
27	....	P.....	15 51 05	....	....	....	4,180	F merged in next 'quake.
		S.....	15 57 02	....	....	....	......	
		L.....	16 07 24	....	....	....	......	
		M.....	16 20 41	....	2,000	....	......	
		F.....	17 ? ?	....	....	....	......	
27	....	P.....	17 30 01	....	....	....	......	Do.
		L.....	17 45 16	....	....	....	......	
		M.....	17 58 32	....	*1,300	....	......	
		L.....	18 33 11	....	....	....	......	
		F.....	19 ? ?	....	....	....	......	
27	....	L.....	19 31 00?	....	....	....	......	
		M.....	19 43 18	....	*250	....	......	
		F.....	20 05 26	....	....	....	......	
29	....	L.....	12 50 47	....	....	....	......	
		M.....	12 59 09	....	*100	....	......	
		F.....	13 ? ?	....	....	....	......	

*Trace amplitude.

TABLE 3.—*Late seismological reports* (*Instrumental*).

New York. *Ithaca.* *Cornell University.* **Heinrich Ries.**

Lat., 42° 26′ 58″ N.; long., 76° 29′ 09″ W. Elevation, 242.6 meters.

Instruments: Two Bosch-Omori, 25 kg., horizontal pendulums (mechanical registration).

Instrumental constants..	*V*	T_0	*ε*
E	13	22	4:1
N	14	25	4:1

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	*μ*	*μ*	*km.*	
Aug. 8	....	e_E....	10 37 30	5	....	....	......	
		L_E....	10 46 20	36	....	....	......	
		L_N....	10 47 35	32	....	....	......	
		F_E....	11 17 ..	....	....	....	......	
		F_N....	11 23 ..	....	....	....	......	
15	....	eP_N...	12 39 24	4	....	....	......	
		e_N....	12 41 15	4	....	....	......	
		e_N....	12 42 24	4	....	....	......	
		e_N....	12 47 06	7	....	....	......	
		e_E....	12 47 07	9	....	....	......	
		e_N....	12 50 06	10	....	....	......	
		e_N....	12 52 27	16	....	....	......	
		e_E....	12 57 10	15	....	....	......	
		e_N....	12 57 28	13	....	....	......	
		L_E....	13 13 10	32	....	....	......	
		L_N....	13 15 14	40	....	....	......	
		F_N....	15 15 ..	....	....	....	......	
		F_E....	15 24 ..	....	....	....	......	

TABLE 3.—*Late seismological reports* (*Instrumental*)—Continued.

New York. *Ithaca.* *Cornell University*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	*μ*	*μ*	*km.*	
Aug. 15	....	eS_E....	18 07 50	6	....	....	......	
		eL_E...	18 24 ..	26	....	....	......	
		F_E....	19 13 ..	....	....	....	......	
17	....	eP_N...	7 03 55	4	....	....	......	
		S_E....	7 12 15	11	....	....	......	
		L_E....	7 27 40	20	....	....	......	
		L_N....	7 29 ..	25	....	....	......	
		F_E....	7 41 ..	....	....	....	......	
23	....	e_E....	7 03 30	....	....	....	......	
		e_N....	7 03 59	6	....	....	......	
		e_E....	7 06 25	16	....	....	......	
		e_N....	7 07 25	8	....	....	......	
		e_E....	7 13 05	16	....	....	......	
		L_E....	7 35 ..	28	....	....	......	
		L_N....	7 37 30	24	....	....	......	
		F_E....	8 45 ..	....	....	....	......	
Sept. 7	....	eP_E...	17 28 45	4	....	....	......	
		eP_N...	17 28 50	4	....	....	......	
		S_E....	17 38 40	8	....	....	......	
		S_N....	17 38 42	9	....	....	......	
		L_E....	17 49 00	20	....	....	......	
		M_E....	18 05 50	21	*3,400	....	......	
		M_N....	18 15 25	17	....	*5,600	......	
		F_N....	21 48 ..	....	....	....	......	
		F_E....	22 13 ..	....	....	....	......	
12	....	e_E....	18 26 36	6	....	....	......	
		eL_N...	18 27 40	13	....	....	......	
		eL_E...	18 28 33	13	....	....	......	
		F.....	18 50 ..	....	....	....	......	
14	....	e_E....	17 22 ..	7	....	....	......	
		eS_E....	17 27 17	8	....	....	......	
		eL_E...	17 45 50	17	....	....	......	
		F_E....	18 30 ..	....	....	....	......	
29	....	eL_N...	12 46 25	30	....	....	......	
		F_N....	13 04 ..	....	....	....	......	
30	....	P_E....	13 43 10	3	....	....	......	
		eP_N...	13 44 50	4	....	....	......	
		S_N....	13 53 07	8	....	....	......	
		eL_N...	14 09 ..	20	....	....	......	
		F_N....	14 40 ..	....	....	....	......	
30	....	eL_N...	18 55 30	20	....	....	......	
		F_N....	20 00 ..	....	....	....	......	

* Trace amplitude.

SEISMOLOGICAL DISPATCHES.[1]

Pine Bluff, Ark., October 4, 1918.

Earth tremors lasting several seconds shortly after 3 o'clock this morning were reported from Pine Bluff, Ark. (Assoc. Pr.)

San Juan, P. R., October 11, 1918.

There were two earthquakes this morning, the first of which occurred at 10:19 and the second three minutes later. They lasted several seconds, shaking and cracking buildings. Light tremors continued to be felt until 1:02 o'clock this afternoon. Gov. Yager estimates the loss of life at 150. Unconfirmed reports state that there was great damage done by the quake in Santo Domingo. (Assoc. Pr.)

San Juan, P. R., October 12, 1918.

A slight additional shock was felt at 4 o'clock this morning. (Assoc. Pr.)

St. Thomas, Virgin Islands, October 12, 1918.

A heavy and prolonged earthquake was felt here at 10:15 o'clock Friday morning (Oct. 11). No damage was done. (Assoc. Pr.)

Mayagüez, P. R., October 14, 1918.

There were more than a dozen distinct shocks felt here in the course of the night. Seventy-five per cent of the masonry buildings at Mayagüez are a total loss. (Assoc. Pr.)

[1] Reported by the organization indicated and collected by the seismological station at Georgetown University, Washington, D. C.

SECTION VI.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Bancroft, Wilder D[wight].
Some properties of fog. 2 tables. 26 cm. (Reprinted from the Journal of physical chemistry, vol. 22, no. 5. May, 1918. p. [309]-336.)

Brotherton, B[ertram].
British rainfall, with special reference to Worcestershire. Worcester. 1917. tables. 22 cm. (Reprinted from Transactions of the Worcestershire naturalists' club for the year ending 31st December, 1916. p. 203-221.)

Flora S[nowden] D[wight].
Some common fallacies about Kansas weather. 23 cm. (Excerpted from the Transactions of the Kansas academy of science, vol. 28. 48th and 49th Annual meeting, Topeka, 1916 and 1917. Topeka. 1918. p. 55-60.)

Great Britain. Meteorological office.
Professional notes, no. 1-3. London. 1918. 3 v. charts. tables. 24½ cm. M. O. 232a-c. Contents: 1. On the interrelation of wind direction and cloud amount at Richmond, by David Brunt. 2. Notes on examples of katabatic wind in the valley of the upper Thames . . . at Benson, Oxon, by E. V. Newnham. 3. Incidence of fog in London 31st, 1918, by C. E. P. Brooks.
The weather of the British coasts . . . London. 1918. viii, 158 p. illus. plates. charts (part. fold.). tables (part. fold.). diagrs. 24 cm. M. O. 230.

Japan. Central meteorological observatory.
Annual report . . . Meteorological observations in Japan for the year 1916. Tôkyô. 1918. cover-title, p. 1., 387 p. fold. map. tables. 30 cm.

Mercanton, P[aul] L[ouis].
La variation annuelle moyenne de la température de l'air à Lausanne, de 1887 à 1916. Lausanne. 1918. cover-title, 8 p. fold. chart. tables. 21½ cm. (Bulletin de la Société vaudoise des sciences naturelles. Vol. 52, no. 194.)

Minas Geraes. Serviço de meteorologia.
. . . Dados meteorologicos. 1915 . . . [Bello Horizonte], 1918. 59 p. charts. tables. 32½ x 34½ cm.

National research council. Division of geology and geography.
Introductory meteorology. New Haven. 1918. xii, 149 [1] p. illus. plates. charts. tables. 23½ cm. Bibliography, p. [147]-149. "Prepared by the staff of the United States Weather Bureau."

Salmon, S. C.
Some factors in the winterkilling of grain crops. 23 cm. (Excerpted from the Transactions of the Kansas academy of science, vol. 28. 48th and 49th Annual meeting, Topeka, 1916 and 1917. Topeka. 1918. p. 129-131.)

Shaw, A. Norman.
Relative humidity. Ottawa. 1917. cover-title. 3 tables. 25 cm. (Reprinted from the Transactions of the Royal society of Canada. Ser. 3, vol. 11. 1917. p. 121-127.)

Spain. Observatorio central meteorológico.
Resumen de las observaciones efectuadas en las estaciones del Servicio meteorológico español durante el año 1916. [Volume] 12. Madrid. 1918. cii, 1., 570 [4] p. fold. map. tables. 24 cm. At head of title: Dirección general del Instituto geográfico y estadístico . . .

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. F. TALMAN, Professor in Charge of Library.

The following titles have been selected from the contents of the periodicals and serials recently received in the library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

Aeronautical journal. London. v. 22. September, 1918.
Turner, Charles C. The structure of gusts. p. 285-286. [Abstract p. 460 this issue.]
Exner, F. M. von. An Austrian memorandum on a meteorological service for the air service in peace time. p. 299-300. [Abstr. from Oesterr. Flug-Zeitschrift.]

British astronomical association. Journal. London. v. 28. June, 1918.
Gibbs, George J. The green flash. p. 255-258. [Describes numerous telescopic observations. Includes sketches.]

Engineering news-record. New York. v. 81. November 7, 1918.
Snow removed by various methods at Milwaukee. p. 857-858.

Great Britain. Meteorological office. Geophysical memoirs. London. no. 12. 1918.
Shaw, Napier. The travel of circular depressions and tornadoes and the relation of pressure to wind for circular isobars. p. 19-44.

Journal of geology. Chicago. v. 26. September-October, 1918.
Emerson, F. V. Loess-depositing winds in Louisiana. p. 532-541.

London, Edinburgh and London philosophical magazine. London. v. 36. October, 1918.
Strutt, R. J. The scattering of light by air molecules. p. 320-321.

Nature. London. v. 102. September 26, 1918.
Dines, J. S. The dynamics of cyclonic depressions. p. 69. [Review of paper by Shaw.]

Royal meteorological society. Quarterly journal. London. October, 1918.
Fairgrieve, James. Suggestions as to the conditions precedent to the occurrence of summer thunderstorms, with special reference to that of June 14, 1914. p. 245-252. [Abstract.]
Brooks, C. E. P. Continentality and temperature—Second paper: The effect of latitude on the influence of continentality on temperature. p. 253-270.
Chapman, S. The lunar atmospheric tide at Greenwich, 1854-1917. p. 271-280.
Christy, Miller. The audibility of the gunfire on the continent at Chignal, near Chelmsford, during 1917. p. 281-284.
Whipple, F. J. W. Seasonal variation in the audibility of distant gunfire. p. 285-289.
Mossman, R. C. Notes on the rainall of Chile. p. 294-302.
Mossman, R. C. Note on summer climate near the east coast of Graham Land. p. 302.
Brooks, C. E. P. The meteorology of Belize, British Honduras, 1888-1917. p. 302-306.

Royal astronomical society of Canada. Journal. Toronto. v. 12. September, 1918.
"Shadow bands" at a total eclipse of the sun. p. 377-379.

Royal society of Edinburgh. Proceedings. Edinburgh. v. 38. pt. 2. 1917-1918.
Davison, Charles. The sound waves and other air waves of the East London explosion. p. 115-129.

Scientific American. New York. v. 119. November 30, 1918.
Russell, Henry Norris. The heavens in December, 1918; lights and shadows, astronomic and aeronautic. p. 440. [Describes "Cellini's halo" (Heiligenschein) seen around shadow of aeroplanes as cast on ground.]

Scientific American supplement. New York. v. 86. November 9, 1918.
Rondeleux. The theory of cyclones and the method of foretelling them. p. 300. [Abstract from Annales Hydrographiques.]

Seismological society of America. Bulletin. Stanford university. June–September, 1918.
Townley, Sidney D. The San Jacinto earthquake of April 21, 1918. p. 45–62.
Rolfe, Frank, & Strong, A. M. The earthquake of April 21, 1918, in the San Jacinto mountains. p. 63–67.
Arnold, Ralph. Topography and fault system of the region of the San Jacinto earthquake. p. 68–73.
MacDonald, Berhard. Remarks on the Sonora earthquake—its behavior at Tepic, Sonora, etc. p. 74–78.
Reid, Harry Fielding. The starting points of earthquake vibrations. p. 79–82.
Klotz, Otto. Analysis of earthquake waves. p. 83–87.
Jaggar, T. A., & Romberg, Arnold. An experiment in teleseismic registration. p. 88–89.

Académie des sciences. Comptes rendus. Paris. Tome 167. 1918.
Véronnet, A. Sur la limite et l'extension d'une atmosphère. Application aux planètes. p. 528–531. (Oct. 7.)

Académie des sciences. Comptes rendus. Paris. Tome 167. 1918—Con.
Véronnet, A. Limite et composition de l'atmosphère terrestre. Aurores boréales, bolides, étoiles filantes. p. 636–638. (Oct. 28.)

Archives des sciences physiques et naturelles. Genève. 4 période. v. 46. September, 1918.
Gautier, Raoul, & Rod, Ernest. Moyennes de 10 à 20 ans pour les éléments météorologiques observées aux fortifications de Saint-Maurice 1908–1917 et 1898–1917. p. 151–176.

Astronomie. Paris. 32 année. Octobre 1918.
Le climat de la région de Paris. p. 359–360. [Gives monthly and annual mean temperatures at Parc St. Maur and Juvisy. 1891–1917.]

Reale accademia dei Lincei. Atti. Roma. v. 27. 1918.
Amerio, Allessandro. pireliometro integrale. p. 288–293. (21 aprile.)
Agamennone, G. Contributo alla teoria del pendolo orizzontale. p. 326–331. (5 maggio.)

Hemel en dampkring. Den Haag. 16 jaarg. September 1918.
Visser, S. W. De draagwijdte van den donder. p. 65–70.
Pinkhof, M. De halo van Heemskerk en Barents. p. 70–73.

SECTION VII.—WEATHER AND DATA FOR THE MONTH.

WEATHER OF OCTOBER, 1918.

P. C. DAY, Climatologist and Chief of Division.

[Dated: Washington, Dec. 2, 1918.]

PRESSURE AND WINDS.

The distribution of the mean atmospheric pressure over the United States and Canada, and the prevailing direction of the winds for October, 1918, are graphically shown on Chart VII, while the means at the several stations, with the departures from the normal, are shown in Tables I and III.

For October, as a whole, the average pressure was below the normal in the Gulf States and northward to the lower Missouri and central Mississippi valleys, in the northwestern Canadian Provinces, and the extreme southern portions of California and Arizona. Elsewhere it was generally above the seasonal average. The departures from the normal were everywhere small, the greatest being 0.10 inch in the extreme eastern Canadian Provinces. (A more detailed discussion of the pressure distribution during October will be found under "Forecasts and warnings.")

The general distribution of atmospheric pressure for the month favored southerly winds in most northern and central portions of the country, while in the southeastern districts they were generally northerly. Elsewhere variable winds prevailed.

TEMPERATURE.

The month opened with cool weather in the Ohio Valley and to the northward, with frost in the Lakes region and the interior of New York and Pennsylvania, and toward the middle of the first decade freezing weather was experienced in portions of North Dakota and Minnesota, and during the next few days it occurred locally in New York and New England. Elsewhere throughout much of the decade the temperature was above the normal, particularly over the central and southern Great Plains and part of the lower Mississippi Valley, where it averaged about 6° a day above the normal. During the remainder of the first half of the month seasonable temperatures prevailed generally and similar conditions existed during the last half of the month, with no unusual fluctuations except that in southwestern California the temperature near the end of the month was decidedly above the seasonal average.

For the month as a whole the temperature average was above the normal in all sections. In portions of the Northeast and Northwest, the excess was about one degree a day, while in portions of the South and the Great Plains States, and the far Southwest the excess was about 6° a day.

PRECIPITATION.

During the first decade rather frequent and heavy rainfall occurred in many localities from the Lakes region to the Atlantic coast; elsewhere east of the Rocky Mountains the falls were mostly unimportant. However, near the close of the decade heavy local rains fell in the central Gulf coast States and the Southern Great Plains region. West of the Rocky Mountains rain set in over the central and northern portions early in the month and continued for several days, relieving the severe drouth that had prevailed in that section, but causing damage to fruit in the process of drying in California. At the beginning of the second decade showery weather prevailed in the Mississippi Valley, and during the next several days the rain area extended over practically all districts east of the Mississippi River. During the latter part of the decade showery weather continued for several days, with some torrential local rains in the lower Mississippi Valley. Rain also fell in the central and northern plateau and Pacific Coast States and at the close of the decade rainfall was general and at a number of points heavy in practically all districts east of the Rocky Mountains. Early in the third decade rains again set in over the Great Plains region and during the following few days unsettled, showery weather prevailed in the Gulf region and interior valleys, with heavy falls in northern Texas, the central Gulf States, and the southern Appalachian region, nearly 6 inches having fallen at Asheville, N. C., in the 24 hours ending with the morning observation of the 25th. Toward the latter part of the decade unsettled, showery weather prevailed for several days from the Gulf northward to the Hudson Bay region and to the eastward, with heavy falls in the Southern States. The month closed with fair weather throughout the central and western districts, except along the north Pacific coast, where light rain prevailed.

For the month as a whole the precipitation was exceptionally heavy in the southern portion of the Appalachian Mountain region and thence southwestward to the Gulf; it was also fairly heavy in western Iowa, eastern Nebraska, over the greater portions of Kansas and Oklahoma, and along the north Pacific coast. In the Atlantic States the amounts were generally light, and but little precipitation occurred in the mountain and plateau States and over the greater part of California and the far Southwest. In the principal agricultural districts the ground was well supplied with moisture at the close of the month, except in the Atlantic Coast States and from the Dakotas westward to the Rocky Mountains and in parts of the far Southwest.

RELATIVE HUMIDITY.

The relative humidity for the month was above the normal throughout the whole country, except locally along the Pacific coast and in portions of the upper Lakes region and westward to the Dakotas, where there were slight deficiencies.

GENERAL SUMMARY.

For October as a whole the weather was favorable for nearly all farming operations. The gathering of corn progressed satisfactorily, although this work was retarded somewhat by rain during the latter part of the month in

southern districts and some damage resulted. The crop was mostly matured before frost and the quality was generally good. The prevailing high temperature was very favorable for the development of the late bolls and the top growth of cotton, especially in the central and eastern portions of the belt; and, while rainy weather caused some delay in picking and ginning, this work made excellent progress. The weather was expecially favorable for winter grains, and the condition of these crops was generally excellent; also the area planted was larger than usual in the Central Valley States. Potato digging made satisfactory progress, and the moderate weather was favorable for the growth of late garden truck in most Southern States. The harvesting of sugar beets progressed favorably and, while sugar cane was backward, the prospect for this crop was generally good. The weather was favorable for pastures, and live stock was in good condition. Citrus fruits in Florida and California progressed satisfactorily and the weather was generally favorable for the maturing and harvesting of other fruits.

Average accumulated departures for October, 1918.

Districts.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	° F.	° F.	° F.	Ins.	Ins.	Ins.	0-10.		P.ct.	
New England	52.6	+2.3	− 8.4	2.31	−1.30	− 4.20	6.0	+0.6	81	+3
Middle Atlantic	59.0	+3.4	− 0.7	1.72	−1.50	− 5.50	5.2	+0.5	75	−1
South Atlantic	67.6	+3.9	+ 5.5	2.70	−1.20	−13.40	6.3	+2.3	80	+3
Florida Peninsula	78.9	+2.2	+ 5.5	5.21	−1.00	−16.00	6.2	+1.6	80	+1
East Gulf	70.3	+4.8	+ 9.1	8.29	+5.50	+ 1.00	6.7	+2.9	81	+8
West Gulf	69.3	+2.7	+ 7.9	3.69	+0.90	− 8.10	5.4	+1.7	68	−4
Ohio Valley and Tennessee	60.7	+3.8	− 1.7	3.32	+0.80	− 3.10	6.0	+1.6	74	+2
Lower Lakes	54.0	+2.2	− 7.5	2.97	0.00	− 1.40	6.0	+0.2	75	+1
Upper Lakes	50.6	+2.9	− 8.4	3.17	+0.40	− 3.00	6.3	+0.3	79	+1
North Dakota	46.6	+4.0	+11.0	0.68	−0.60	− 3.70	5.1	−0.1	69	+3
Upper Mississippi Valley	56.1	+3.3	+ 0.7	2.77	+0.30	− 2.00	5.8	+1.3	74	+1
Missouri Valley	57.0	+4.4	+14.6	2.82	+0.90	− 3.80	5.1	+1.0	70	+4
Northern slope	49.4	+4.8	+ 9.1	0.86	−0.10	+ 1.30	5.2	+0.9	68	+4
Middle slope	59.4	+3.8	+10.9	3.00	+1.50	+ 0.30	5.4	+1.9	69	+8
Southern slope	64.6	+2.2	+13.6	3.04	+0.50	− 6.60	3.9	+0.2	65	+1
Southern Plateau	61.7	+1.9	+ 1.6	1.00	+0.40	− 0.20	2.7	+0.5	52	+8
Middle Plateau	53.6	+2.8	+ 5.6	0.74	−0.10	− 0.50	4.2	+0.9	59	+9
Northern Plateau	53.3	+3.9	+17.5	1.52	+0.30	− 1.00	5.7	+1.1	67	+6
North Pacific	54.1	+2.4	+13.1	4.51	+0.70	− 3.70	7.1	+0.7	85	+2
Middle Pacific	61.1	+2.4	+ 6.2	0.45	−1.10	− 4.20	3.6	−0.2	69	+2
South Pacific	68.4	+6.0	+22.5	0.34	−0.50	+ 2.30	3.0	−0.1	64	−3

WEATHER CONDITIONS OVER THE NORTH ATLANTIC DURING OCTOBER, 1917.

The data presented are for October, 1917, and comparison and study of the same should be in connection with those appearing in the Review for that month.

Chart IX (XLVI-91) shows the averages of pressure, air temperature, water-surface temperature, and the prevailing direction of the wind at 7 a. m., 75th meridian time (Greenwich mean noon).

Notes on the location and courses of the more severe storms of the month are included in the following general summary.

PRESSURE.

The distribution of the mean atmospheric pressure for the month differed considerably from the normal in some respects. The North Atlantic HIGH, with a crest of 30.3 inches, was practically normal in position but of greater intensity than usual. The Icelandic LOW of 29.4 inches was well developed and considerably below the normal in intensity, the gradient between the two areas being remarkably steep. The pressure over the western division of the ocean was near the normal in the southern section and slightly above in the northern.

The following table gives for a number of selected 5-degree squares the average pressure for each of the three decades of the month, as well as the highest and lowest individual readings reported during the month within the respective squares.

Pressure over the North Atlantic Ocean during October, 1917, by 5-degree squares.

Position of 5-degree squares.		Decade means.			Extremes.			
					Highest.		Lowest.	
Latitude.	Longitude.	I.	II.	III.*	Pressure.	Date.	Pressure.	Date.
°	°	Inches.	Inches.	Inches.	Inches.	October.	Inches.	October.
60-65 N	20-25 W	29.55	29.77	29.70	30.22	13	29.18	24
60-65 N	0- 5 E	29.39	29.61	29.25	30.04	19	28.73	25
55-60 N	35-40 W	29.82	29.88	30.00	30.32	9,13	29.38	2
55-60 N	10-15 W	29.57	29.63	29.51	29.92	5	29.09	24
50-55 N	55-60 W	29.94	29.97	30.05	30.50	24	29.47	5
50-55 N	25-30 W	30.02	29.92	29.99	30.39	13	29.52	30
50-55 N	0- 5 W	29.68	29.75	29.72	30.20	20	29.07	13
45-50 N	65-70 W	30.01	30.03	30.04	30.48	24	29.50	1
45-50 N	40-45 W	30.22	30.11	30.21	30.52	4	29.70	30
45-50 N	10-15 W	30.08	29.99	30.01	30.39	5	29.70	13,30
40-45 N	50-55 W	30.21	30.20	30.18	30.47	3	29.80	1
40-45 N	25-30 W	30.36	30.24	30.27	30.60	5,21	29.80	31
35-40 N	75-80 W	30.11	30.11	30.08	30.30	2	29.60	30
35-40 N	35-40 W	30.39	30.31	30.23	30.60	5	30.00	31
35-40 N	10-15 W	30.17	30.18	30.16	30.37	6	30.03	27
30-35 N	50-55 W	30.22	30.20	30.09	30.36	5	29.98	28
30-35 N	25-30 W	30.30	30.26	30.21	30.50	11	30.06	19
25-30 N	90-95 W	30.07	30.00	30.05	30.21	23	29.80	25
25-30 N	60-65 W	30.07	30.10	30.07	30.20	18,30	29.96	1,25
25-30 N	15-20 W	30.10	30.15	30.10	30.30	11	29.99	25
20-25 N	75-80 W	29.99	29.97	29.97	30.25	7	29.91	20,24
20-25 N	50-55 W	30.07	30.05	30.00	30.20	6	29.95	25
15-20 N	35-40 W	30.02	30.01	29.98	30.11	4,6	29.93	21
10-15 N	80-85 W	29.88	29.86	29.85	29.92	2	29.80	22

* Mean of last 11 days of the month.

The mean values presented in the above table are based on the interpolated daily pressure for each square on the daily synoptic charts of the North Atlantic, compiled by the marine section of the Weather Bureau. The extremes are the highest and lowest actual readings absverved within the respective squares.

GALES.

There were fewer gales than usual over the entire ocean, with the exception of a limited area in the eastern part of the steamer lanes, where the number of days on which they were observed was slightly above the normal.

On October 3 a LOW of 29.13 inches was central in the vicinity of the Shetland Islands, and a vessel about 250 miles east of that point encountered a westerly gale of over 60 miles an hour. On the same day a HIGH with a crest of 30.54 inches was off the Canadian coast, and moderate gales were reported by a few vessels between the two areas.

On the 4th this LOW surrounded the coast of the Scandinavian peninsula, the barometer at Christiansund,

Norway, reading 28.93 inches, with strong northerly gales between there and Iceland. On the same day a LOW of less intensity (I on Chart IX) was central near Quebec, while moderate winds prevailed along the Canadian coast. LOW I moved northeastward with a fair rate of speed, and on the 5th covered the east coast of Labrador; it had increased somewhat in intensity, as moderate southerly and southeasterly gales were reported from the easterly quadrants, while fog occurred off the Banks of Newfoundland. LOW I increased in its rate of translation, and on the 6th the center was near latitude 48°, longitude 30°, the wind and weather conditions remaining about the same as on the previous day. On the 7th the center of this disturbance was near latitude 60°, longitude 15°; it had increased considerably in intensity, and strong northwesterly gales were encountered in the westerly quadrants. This LOW remained practically stationary during the next 48 hours, although the storm area had increased in extent, and on the 8th and 9th winds of gale force swept over a large territory between the European coast and the 40th meridian.

On the 12th a well-developed LOW of 28.96 inches surrounded the north coast of Scotland, and heavy gales prevailed between the 45th and 62d parallels, and the European coast and the 25th meridian. This LOW moved eastward and on the 13th covered the North Sea, remaining about the same in intensity, with a minimum barometric reading of 28.95 inches. Gales still swept the European coast, although they did not extend as far west as on the 12th.

From the 13th to the 18th there were a number of shallow depressions over various parts of the ocean, and light to moderate winds prevailed during that period. On the 19th a moderate LOW was central near latitude 57°, longitude 23°, and southerly gales occurred in the easterly quadrants. On the same day a HIGH with a crest of 30.54 inches surrounded the Canadian coast, and vessels a short distance east of the Banks of Newfoundland reported northerly winds of gale force, where the barometer reading was over 30.2 inches. By the 20th the LOW had moved about 15° toward the east, and southerly gales occurred off the European coast. The HIGH had drifted slowly southward and the winds over the western division of the ocean were from light to moderate.

On the 22d the North Atlantic HIGH had become unusually well developed, with a crest of 30.62 inches, and vessels near the Azores, about 300 miles south of the crest, reported northeasterly gales of from 40 to 50 miles an hour, while the barometer readings ranged from 30.40 to 30.50 inches, at the same time there was a LOW of marked intensity off the Scandinavian coast, but on account of lack of reports no information is available as to weather conditions. On the 23d the positions of both the high and low areas were nearly the same as on the previous day, and winds of gale force still prevailed over the azores, although of somewhat diminished force.

On the 24th, Norfolk, Va., was the center of a LOW of 29.60 inches, and moderate northwesterly gales were encountered off the coast between Hatteras and Savannah. On the same day a disturbance covered the territory between Iceland and the Shetland Islands, and southwesterly gales with hail were reported from the southern quadrants. On the 25th, the American LOW, having moved northward, was central near Montreal, and a few reports were received from vessels off the coast between Halifax and New York, that denoted winds of gale force. The European LOW had moved rapidly eastward, increasing in intensity, and on the 25th it was central near Skudesnaes, Norway, where the barometer reading was 28.63 inches, the lowest reported during the month. Violent gales, with hail, swept a large territory between the 25th meridian and the European coast, the storm area extending as far south as the 45th parallel. On the 26th the Canadian LOW had begun to fill in, and the Scandinavian disturbance, while remaining nearly stationary in position, had decreased slightly in intensity, although heavy winds with hail were still encountered north of the 55th parallel, and east of the 20th meridian. On the 27th this LOW was in practically the same region as on the previous day, and heavy weather still prevailed in the vicinity of the Shetland Islands and adjacent territory. This depression covered a large area between the 20th meridian and the Scandinavian peninsula until the end of the month, although few reports of heavy winds were received from vessels within these limits.

From the 28th to the 31st there was a LOW over eastern Canada, and winds of gale force occurred during that period between the 40th meridian and the American coast.

AIR TEMPERATURE.

The average temperature of the air over the greater part of the North Atlantic ocean was below the normal. Negative departures of from 4° to 5° were the rule over the eastern division, north of the 40th parallel, while between the Madeiras and the Azores, the departures were slightly less. In the waters adjacent to the Canadian and New England coasts, as well as in the North East trade wind limits, the temperatures were from 2° to 3° above the normal, and in the Caribbean Sea and Gulf of Mexico the departures were practically zero.

The seasonal fall in temperature during the month was comparatively small, as were the daily fluctuations. In the square that includes the east coast of Labrador, where the greatest changes usually occur, the range was only 8°, from 41° on the 31st to 49° on a number of different days.

The following table gives the temperature departures for the month at a number of Canadian and United States Weather Bureau stations on the Atlantic and Gulf coast:

	°F.		°F.
St. Johns, N. F	+4.4	Norfolk, Va	−3.1
Sydney, C. B. I	+4.4	Hatteras, N. C	−2.8
Halifax, N. S	+3.0	Charleston, S. C	−3.4
Eastport, Me	−0.4	Key West, Fla	+0.7
Portland, Me	−2.1	Tampa, Fla	0.0
Boston, Mass	−0.4	Mobile, Ala	−3.4
Nantucket, Mass	−1.9	New Orleans, La	−3.1
Block Island, R. I	−3.6	Galveston, Tex	−3.8
New York, N. Y	−3.6	Corpus Christi, Tex	−2.4

WATER SURFACE TEMPERATURE.

In the waters adjacent to the American coast the departures from the normal of the average monthly water surface temperature did not differ materially from that of the air. Off the Banks of Newfoundland the departures were irregular, ranging from +3° to −3°, and along the American coast from +2° in the south to −2° in the north. In the western division of the ocean, between the 30th and 45th parallels, as well as in the Gulf of Mexico, the water temperatures were as a rule from 1° to 4° below the normal. In the region of the Azores the departures were slightly positive, and throughout the northeast trade wind region they varied from −1° to +2°.

The greatest daily fluctuation in the water temperature occurred as usual in the square between latitude

45°-50°, longitude 45°-50°, where the range was from 48° to 59°, both extremes occurring on a number of different days.

FOG.

Fog was unusually rare during the month, the greatest amount occurring in the square between latitude 45°-50°, longitude 45°-50°, where it was observed on five days, a percentage of 16, while the normal for that square is 30 per cent or more. Fog was reported on one day off the North Carolina coast, and also in the Azores, while the steamer lanes were apparently entirely free from it, although so few vessels reports were received over the eastern section, that it was impossible to determine the conditions accurately.

HAIL AND SNOW.

The greatest amount of hail occurred in the square between latitude 55°-60°, longitude 25°-30°, where it was reported on three days, while it was encountered on two days in each of the two squares immediately to the eastward.

Only one report of snow was received during the month; it was observed on the 5th in the square between latitude 55°-60°, longitude 15°-20°.

Winds of 50 mis./hr. (22. 4 m./sec.) or over, during October, 1918.

Station.	Date.	Velocity.	Direction.	Station.	Date.	Velocity.	Direction.
Buffalo, N. Y.	5	54	sw.	North Head, Wash.	27	68	s.
Do.	13	54	sw.	Pensacola, Fla.	23	53	se.
Duluth, Minn.	12	65	w.	Do.	27	50	s.
Mount Tamalpais, Cal.	14	50	s.	St. Louis, Mo.	27	66	sw.
North Head, Wash.	4	72	se.	Tatoosh Island, Wash.	10	68	s.
Do.	9	56	se.	Do.	11	62	s.
Do.	26	52	se.	Do.	27	68	s.

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, October, 1918.

Section.	Temperature.								Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	68.6	+4.8	3 stations	94	6†	Evergreen	38	31	8.74	+5.83	Demopolis	16.57	Camp Hill	3.36
Arizona	63.4	+2.0	2 stations	105	1†	Greer	11	27	0.62	−0.24	Nutrioso	2.65	2 stations	0.00
Arkansas	65.6	+3.8	Marked Tree	100	5	Bentonville	30	31	3.99	+1.31	Eldorado	8.58	Osceola	1.10
California	62.9	+1.8	Azusa	105	12	3 stations	18	16†	1.02	−0.43	Redding	6.29	11 stations	0.00
Colorado	49.3	+2.8	Wiggins	96	6	Dillon	−1	1	1.23	−0.07	Cuchara Camps	3.42	Crawford	T.
Florida	76.6	+3.9	De Land	96	7	Marianna	53	31	5.84	+1.42	Merritts Island	13.78	Cedar Keys	0.30
Georgia	69.5	+5.1	Hazlehurst	97	7	2 stations	38	15	4.58	+1.71	Clayton	15.53	Valdosta	1.45
Hawaii (September)	75.3	+0.8	2 stations	97	3†	Volcano Observatory	51	22	2.76	−2.84	Eke Maui	13.50	6 stations	0.00
Idaho	48.8	+2.2	2 stations	88	2†	American Falls	10	27	2.32	+0.74	Oxford ranger station.	6.19	Challis	0.39
Illinois	58.1	+3.1	4 stations	90	5†	2 stations	28	1	3.13	+0.75	Antioch	4.96	Flora	1.90
Indiana	57.8	+3.5	2 stations	89	2†	La Porte	23	1	2.88	+0.41	Marengo	5.35	Vevay	0.98
Iowa	55.1	+4.3	Shenandoah	93	12	Sibley	21	29	3.64	+1.18	Thurman	7.56	Mt. Pleasant	1.36
Kansas	60.3	+3.8	2 stations	97	5†	4 stations	21	31	3.92	+2.04	Bazaar	8.05	Gove	0.93
Kentucky	62.3	+4.5	3 stations	91	5†	2 stations	32	15	3.81	+1.31	Harlan	6.91	Henderson	1.91
Louisiana	71.6	+4.1	Angola	100	6	2 stations	33	28	9.18	+6.11	Cheneyville	15.42	Plain Dealing	3.02
Maryland-Delaware	59.6	+3.2	Western Port, Md.	89	17	Oakland, Md.	21	22	1.36	−1.67	Oakland, Md.	3.22	Delaware City, Del.	0.16
Michigan	50.6	+2.2	Ewen	87	12	Iron River	14	3	3.26	+0.62	Onaway	6.04	2 stations	1.45
Minnesota	48.2	+2.2	Winnebago	87	12	Grand Rapids	12	3	2.36	+0.19	Glencoe	4.87	Hallock	0.75
Mississippi	69.2	+4.5	3 stations	96	6†	2 stations	34	28	8.98	+7.24	Pearlington	18.17	Hernando	2.06
Missouri	60.6	+3.5	Eldon	95	7	Maryville	28	28†	3.37	+0.71	Lamar	7.95	Houston	1.18
Montana	48.2	+4.3	Crow Agency	89	2†	Foster	6	26	0.89	−0.21	Haugan	3.88	Fort Shaw	T.
Nebraska	55.1	+4.2	3 stations	94	4†	Halsey	10	28	2.62	+1.05	West Point	7.94	Alliance	0.43
Nevada	53.2	+3.1	Logandale	98	2	Millett	10	26	0.98	+0.23	Mahoney ranger station.	2.48	Thorne	T.
New England	50.9	+2.5	Fitchburg, Mass	82	29	Van Buren, Me.	19	17	2.89	−0.75	Enosburg Falls, Vt.	8.33	Providence, R. I.	0.65
New Jersey	57.0	+3.0	Indian Mills	84	29	Charlotteburg	22	22†	1.25	−2.43	Tuckerton	2.36	2 stations	0.74
New Mexico	55.0	+1.6	2 stations	98	2†	2 stations	10	27	1.95	+0.79	Mountain Park	4.48	Cloverdale	0.41
New York	52.0	+1.9	Wappingers Falls	82	29	Bolivar	19	22	3.35	+0.50	Salisbury	7.52	Bedford Hills	0.43
North Carolina	62.9	+3.5	5 stations	90	6†	Banners Elk	26	15	5.05	+1.57	Highlands	22.73	Louisburg	0.29
North Dakota	46.2	+2.4	Hettinger	90	14	Lamoine	4	28	0.54	−0.46	Larimore	1.91	2 stations	0.00
Ohio	56.6	+3.2	Jackson	89	3†	Millport	22	22	2.71	+0.18	Green	4.88	Sandusky	1.13
Oklahoma	65.0	+3.4	Mangum	106	8	Kenton	27	31	5.53	+3.18	Frederick	10.29	Smithville	1.73
Oregon	52.9	−0.3	Williams	91	1†	Blitzen	10	25	2.44	−0.19	Cascade Locks	8.66	Valley Falls	0.26
Pennsylvania	55.5	+3.5	Lebanon	85	15	Mount Pocono	19	19	3.17	−0.95	Mount Pocono	5.75	Ephrata	0.44
Porto Rico	78.2	0.0	Naguabo	99	10	Lares	58	1†	7.31	−1.40	Carite Camp	14.68	Isabela	1.08
South Carolina	67.3	+4.0	2 stations	92	7	Cheraw	33	16†	3.75	+0.61	Walhalla	13.91	Georgetown	0.50
South Dakota	51.5	+3.4	Hermosa	94	14	3 stations	9	28†	0.87	−0.41.	Marion	3.23	2 stations	T.
Tennessee	63.7	+4.5	Savannah	92	6	Mountain City	26	15	5.41	+2.47	Dunlap	9.12	Huntingdon	1.42
Texas	68.8	+2.0	4 stations	100	6†	Amarillo	26	27	3.87	+1.38	Tulia	11.58	Fort Davis	0.00
Utah	51.4	+3.2	Lower Mill Creek	96	15	Black's Fork	2	26†	1.42	+0.15	Mammoth ranger station.	5.30	Escalante	0.12
Virginia	60.8	+3.5	Franklin	89	6	Burkes Garden	22	15	2.44	−0.72	North Holston	7.78	Mayhurst	0.45
Washington	52.0	+2.5	Hatton	89	2	3 stations	20	22†	3.95	+1.34	Snoqualmie Pass	20.32	Wapato	0.28
West Virginia	58.2	+3.2	2 stations	89	16†	Marlinton	20	15	3.69	+0.88	Green Sulphur Springs.	7.53	Harpers Ferry	1.59
Wisconsin	49.8	+2.3	La Crosse	86	12	Solon Springs	17	3	2.43	−0.12	Racine	3.77	Mauston	0.88
Wyoming	46.8	+3.7	4 stations	85	12†	Foxpark	0	26	0.95	−0.02	Afton	4.84	Wyncote	T.

† Other dates also.

DESCRIPTION OF TABLES AND CHARTS.

(See the REVIEW, January, 1918, p. 48.]

TABLE I.—*Climatological data for Weather Bureau Stations, October, 1918.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Precipitation.			Wind.										
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Total.	Departure from normal.	Days with .01 inch or more.	Total movement.	Prevailing direction.	Maximum velocity: Miles per hour.	Maximum velocity: Direction.	Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England.							52.6	+2.3										81	2.31	−1.3										6.0		
Eastport	76	67	85	30.00	30.08	+0.08	48.2	+1.6	66	11	54	33	19	42	22	45	42	83	3.33	−0.5	13	7,799	nw.	40	ne.	6	8	4	19	7.0	....	....
Greenville, Me	1,070	6	....	28.91	30.09	....	45.4	....	68	29	54	23	20	37	34	....	....	....	5.38	....	16	....	....	....	....	....	9	6	16	....	2.5	....
Portland, Me	103	82	117	30.00	30.12	+ .08	50.2	+1.1	76	11	58	34	8	43	30	46	42	79	2.39	−1.3	15	6,258	s.	34	s.	20	11	5	15	5.7	....	....
Concord	288	70	79	29.81	30.12	+ .07	50.8	+2.1	79	29	62	27	20	40	41	....	....	....	1.14	−2.1	10	2,529	se.	11	sw.	20	14	4	13	5.4	....	....
Burlington	404	11	48	29.66	30.10	+ .06	49.0	+2.1	68	27	57	28	8	41	31	....	....	....	6.75	+3.6	13	8,231	s.	48	s.	28	6	8	17	6.8	....	....
Northfield	876	12	60	29.16	30.12	+ .08	47.6	+4.0	74	29	59	23	19	36	41	43	41	85	5.21	+2.7	15	5,419	s.	32	s.	20	3	7	21	8.0	....	....
Boston	125	115	188	29.98	30.12	+ .07	56.2	+3.9	79	29	64	38	19	48	29	50	46	76	0.99	−2.9	7	6,610	sw.	30	n.	18	8	12	11	5.8	....	....
Nantucket	12	14	90	30.11	30.12	+ .07	55.0	+0.5	70	3	61	40	20	49	20	52	49	84	2.12	−1.3	11	11,698	sw.	47	ne.	7	13	6	12	5.8	....	....
Block Island	26	11	46	30.10	30.13	+ .08	55.6	+0.3	69	11	61	42	19	50	17	53	52	89	0.86	−3.2	9	11,337	sw.	44	ne.	7	11	4	16	6.5	....	....
Providence	160	215	251	29.94	30.12	+ .07	54.4	+2.2	76	30	64	36	10	45	30	49	45	75	0.65	−3.2	7	7,947	sw.	43	nw.	21	11	11	9	5.0	....	....
Hartford	159	122	140	29.94	30.12	+ .06	55.3	+4.1	77	11	66	34	19	45	33	50	47	81	0.82	−3.0	7	5,352	s.	30	sw.	20	12	10	9	4.9	....	....
New Haven	106	117	155	30.02	30.13	+ .07	56.0	+3.2	77	11	65	36	19	47	28	51	47	77	1.20	−2.7	9	6,094	s.	32	sw.	20	11	9	11	5.1	....	....
Middle Atlantic States.							59.0	+3.4										75	1.72	−1.5										5.2		
Albany	97	102	115	30.00	30.11	+ .05	54.0	+3.6	78	11	63	32	24	45	31	48	44	77	1.67	−1.3	9	5,650	s.	37	s.	20	11	11	9	5.5	....	....
Binghamton	871	10	69	29.18	30.11	+ .05	54.0	+4.8	76	29	65	29	19	43	35	....	....	....	4.05	+0.9	13	3,346	s.	25	n.	14	8	11	12	5.9	....	....
New York	314	414	454	29.79	30.12	+ .06	58.6	+3.0	75	11	66	40	8	51	22	52	47	71	0.83	−2.9	7	11,444	s.	49	n.	18	10	14	7	5.0	....	....
Harrisburg	374	94	104	29.74	30.14	+ .06	58.2	+4.2	80	16	68	38	19	49	34	51	46	72	2.17	−0.8	8	4,132	s.	22	n.	18	8	12	11	5.2	....	....
Philadelphia	117	123	190	30.01	30.13	+ .06	60.6	+4.3	79	29	69	42	19	52	25	55	52	80	0.69	−2.4	5	6,703	sw.	28	n.	7	11	11	9	5.0	....	....
Reading	325	81	98	29.79	30.14	....	58.6	....	79	6	69	36	19	48	30	51	46	70	0.74	−2.5	6	4,516	se.	27	nw.	6	11	10	10	5.1	....	....
Scranton	805	111	119	29.25	30.13	+ .06	55.4	+4.0	76	11	65	32	19	46	32	50	47	81	3.25	+0.3	14	4,354	sw.	29	s.	30	9	9	13	5.6	....	....
Atlantic City	52	37	48	30.08	30.14	+ .07	59.5	+2.1	78	3	66	40	15	53	25	55	52	79	1.43	−1.9	7	5,311	sw.	27	ne.	18	12	12	7	4.5	....	....
Cape May	18	13	49	....	30.16	+ .09	60.0	+0.4	78	3	67	42	8	53	23	....	....	....	1.56	−1.7	8	6,113	se.	29	se.	30	14	11	6	4.2	....	....
Sandy Hook	22	10	57	30.11	30.13	....	58.8	....	74	13	65	45	19	52	19	53	49	77	0.74	....	6	10,576	s.	47	nw.	14	12	13	6	4.7	....	....
Trenton	190	159	183	29.91	30.12	....	58.1	....	79	29	68	38	20	48	29	51	47	76	0.74	−2.7	6	7,329	s.	34	n.	18	12	5	14	5.3	....	....
Baltimore	123	100	113	30.01	30.14	+ .06	60.8	+3.3	82	6	70	40	23	52	31	54	49	70	0.76	−2.3	5	4,153	se.	24	n.	7	9	15	7	4.9	....	....
Washington	112	62	85	30.01	30.13	+ .05	60.6	+4.0	83	6	71	34	23	50	35	53	48	73	0.86	−2.2	6	4,004	s.	26	nw.	31	8	13	10	5.2	....	....
Lynchburg	681	153	188	29.39	30.13	+ .04	61.0	+4.1	87	16	73	30	23	49	44	53	48	73	0.95	−2.4	6	4,559	w.	34	n.	7	13	8	10	5.2	....	....
Norfolk	91	170	205	30.05	30.15	+ .08	65.2	+3.9	84	6	73	48	16	58	27	58	55	78	0.79	−3.1	5	9,548	ne.	41	s.	30	10	12	9	5.2	....	....
Richmond	144	11	52	30.00	30.15	+ .07	62.2	+2.4	85	3	74	35	23	51	36	54	50	74	0.59	−2.7	5	5,702	se.	34	nw.	3	9	12	10	5.4	....	....
Wytheville	2,293	49	55	27.76	30.13	+ .04	56.6	+3.0	81	16	67	31	15	46	45	51	48	81	6.38	+3.2	11	3,942	w.	38	sw.	30	14	7	10	4.8	....	....
South Atlantic States.							67.6	+3.9										80	2.70	−1.2										6.3		
Asheville	2,255	70	84	27.80	30.14	+ .05	59.1	+3.8	79	6	69	36	15	50	43	53	50	79	11.32	+8.4	13	5,984	se.	28	se.	30	10	9	12	6.0	....	....
Charlotte	773	153	161	29.29	30.12	+ .04	64.0	+2.9	86	6	73	42	23	55	32	57	54	77	3.00	−0.2	7	3,673	ne.	25	sw.	30	10	6	15	6.0	....	....
Hatteras	11	12	50	....	....	....	67.7	+1.7	83	18	74	54	15	62	19	64	60	81	1.09	−4.1	7	....	ne.	....	....	....	9	14	8	....	....	....
Manteo	12	4	46	....	....	....	65.7	....	82	12	75	39	16	56	....	....	....	....	1.45	−4.6	4	....	ne.	....	....	....	18	7	6	....	....	....
Raleigh	376	103	110	29.73	30.13	+ .06	64.2	+3.7	85	6	74	42	23	54	31	57	53	75	0.76	−2.7	4	5,553	ne.	26	ne.	18	9	8	14	5.3	....	....
Wilmington	78	81	91	30.04	30.12	+ .06	67.2	+3.9	85	6	76	47	23	58	25	61	59	81	0.32	−3.4	4	5,478	ne.	29	sw.	31	10	12	9	5.3	....	....
Charleston	48	11	92	30.05	30.10	+ .04	70.7	+3.6	86	6	77	56	23	65	20	65	63	81	1.66	−2.3	4	8,452	ne.	38	ne.	19	6	13	12	6.1	....	....
Columbia, S. C	351	41	57	29.74	30.12	+ .05	67.8	+3.8	89	6	77	46	10	59	32	59	55	72	1.41	−1.4	5	5,321	ne.	28	sw.	30	10	8	13	5.9	....	....
Greenville, S. C	1,013	113	122	29.01	30.10	....	63.7	....	84	6	71	43	16	56	33	57	53	75	11.41	....	9	5,714	ne.	35	w.	31	11	7	13	5.5	....	....
Augusta	180	62	77	29.90	30.09	+ .02	69.2	+5.6	89	6	78	46	10	60	33	62	60	81	3.21	+0.9	8	4,217	e.	28	nw.	30	4	7	20	7.5	....	....
Savannah	65	150	194	30.01	30.08	+ .03	71.6	+5.3	89	7	78	56	9	65	21	66	64	86	1.52	−2.0	9	7,942	ne.	33	e.	19	6	6	19	7.4	....	....
Jacksonville	43	200	245	29.99	30.04	+ .02	74.5	+4.9	88	7	79	57	31	70	18	70	69	88	3.97	−1.1	13	9,208	ne.	36	se.	24	5	10	16	6.9	....	....
Florida Peninsula.							78.9	+2.2										80	5.21	−1.0										6.2		
Key West	22	10	64	29.92	29.94	.00	80.0	+1.3	88	1	85	70	13	75	15	75	73	82	7.94	+2.6	18	7,069	ne.	39	e.	25	8	11	12	5.6	....	....
Miami	25	71	79	29.96	29.99	....	78.9	+1.1	86	31	83	68	28	75	14	74	72	78	4.82	−5.7	14	7,207	e.	28	e.	15	6	13	12	6.2	....	....
Sand Key*	23	39	72	29.91	29.94	.00	78.7	....	84	1	82	70	14	75	11	75	73	80	6.34	....	18	8,638	e.	44	s.	15	4	7	13	6.3	....	....
Tampa	35	79	92	29.96	29.99	+.01	77.9	+4.1	91	7	86	63	31	70	21	71	69	82	2.88	−0.1	10	4,855	ne.	25	e.	15	3	14	14	6.9	....	....
East Gulf States.							70.3	+4.8										81	8.29	+5.5										6.7		
Atlanta	1,174	190	216	28.87	30.10	+.03	65.8	+3.4	84	6	74	47	31	58	22	59	55	74	4.04	+1.7	10	8,049	e.	34	w.	31	9	5	17	6.7	....	....
Macon	370	78	87	29.69	30.08	+.02	68.9	+5.2	89	6	78	47	10	60	31	61	58	74	5.14	+3.0	9	4,519	ne.	24	se.	24	6	6	19	7.1	....	....
Thomasville	273	49	58	29.74	30.03	−.01	73.0	+4.8	88	6	80	51	31	66	24	66	64	82	1.65	−1.8	5	3,576	ne.	23	e.	23	3	9	19	7.7	....	....
Pensacola	56	149	185	29.94	30.00	−.03	73.5	+4.1	83	7	78	54	31	69	17	70	68	86	8.09	+4.0	16	10,641	e.	53	se.	23	5	9	17	6.8	....	....
Anniston	741	9	57	29.29	30.08	+.01	66.2	+3.8	86	5	75	41	31	57	32	....	....	....	8.65	+6.3	10	4,779	se.	26	se.	8	8	9	14	5.9	....	....
Birmingham	700	11	48	29.30	30.06	−.01	68.2	+3.8	88	4	76	42	31	60	26	60	57	78	10.24	+8.5	16	5,200	e.	27	se.	27	9	9	13	5.7	....	....
Mobile	57	125	161	29.93	29.99	−.05	73.8	+6.7	88	4	80	53	31	67	22	68	67	85	10.57	+7.4	16	7,434	e.	45	e.	23	5	11	15	6.7	....	....
Montgomery	223	100	112	29.80	30.05	−.01	70.8	+5.1	88	6	78	48	31	63	24	63	60	77	5.32	+2.9	13	5,026	e.	20	e.	15	6	13	12	6.5	....	....
Corinth	469	6	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Jackson	304	5	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Meridian	375	85	93	29.62	30.01	−.05	69.4	+6.4	89	6	77	46	28	62	28	64	61	82	8.55	+5.8	14	3,899	ne.	27	se.	23	4	8	19	7.3	....	....
Vicksburg	247	65	74	29.74	30.02	−.04	69.4	+4.1	91	7	77	42	28	62	28	63	61	85	17.26	+14.5	16	4,589	se.	23	w.	27	8	4	19	6.8	....	....
New Orleans	51	76	84	29.92	29.97	−.06	74.6	+5.1	88	8	81	55	28	68	16	69	67	85	11.07	+8.1	14	4,865	se.	30	e.	15	6	11	14	6.4	....	....
West Gulf States.							69.3	+2.7										68	3.69	+0.9										5.4		
Shreveport	249	77	93	29.73	30.00	−.05	68.8	+3.2	91	4	77	40	28	61	30	62	59	79	4.25	+1.1	11	4,550	n.	24	se.	26	11	5	15	5.9	....	....
Bentonville	1,303	11	44	28.64	30.00	−.05	62.4	+4.4	87	6	72	30	31	52	34	....	....	....	4.93	+2.1	12	2,635	e.	19	s.	28	16	5	10	4.7	....	....
Fort Smith	457	79	94	29.52	29.99	−.06	66.6	+4.9	90	6	75	37	28	58	33	59	56	77	2.94	+0.1	7	5,296	e.	30	sw.	27	11	6	14	5.6	....	....
Little Rock	357	139	147	29.64	30.02	−.04	66.5	+3.6	89	6	74	38	28	59	28	60	57	78	4.14	+1.6	11	5,271	e.	29	sw.	27	13	4	14	5.8	....	....
Brownsville	57	4	26	....	....	....	77.4	....	96	7	88	50	27	67	34	....	....	....	3.37	....	6	....	n.	....	....	....	....	....	....	....	....	....
Corpus Christi	20	69	77	29.96	29.98	−.02	74.2	+1.6	87	13	81	50	27	67	26	69	66	81	5.54	+3.5	9	6,292	se.	33	se.	25	11	10	10	5.0	....	....
Dallas	512	109	117	29.43	29.97	....	68.8	....	89	4	78	42	27	60	27	....	....	....	6.60	....	6	5,230	se.	38	s.	28	11	9	11	5.1	....	....
Fort Worth	670	106	114	29.27	29.98	−.05	69.0	+2.7	91	4	78	40	27	60	29	60	55	69	3.31	+0.8	7	6,067	se.	39	sw.	28	11	8	12	5.3	....	....
Galveston	54	106	114	29.92	29.98	−.05	72.8	+0.4	84	20	78	47	27	67	27	67	65	81	2.78	−1.4	9	6,500	n.	34	nw.	27	7	6	18	6.3	....	....
Houston	138	111	121	29.83	29.97	....	72.2	+2.3	90	4	80	46	27	64	31	....	....	....	8.44	....	11	4,845	nw.	34	w.	26	9	12	10	5.4	....	....
Palestine	510	64	72	29.46	29.99	−.04	69.0	+2.8	90	3	78	43	27	60	31	61	58	78	2.51	−1.1	9	4,317	ne.	25	w.	26	11	2	18	5.9	....	....
Port Arthur	304	58	66	29.92	29.96	....	71.2	....	87	8	78	45	27	64	24	66	64	85	9.19	....	11	6,213	n.	30	nw.	26	7	14	10	5.4	....	....
San Antonio	701	119	132	29.26	29.98	−.03	71.6	+2.4	93	7	82	42	27	62	28	62	58	71	4.05	+2.6	8	4,794	n.	39	nw.	26	13	12	6	4.5	....	....
Taylor	582	55	63	29.38	30.00	....	69.5	+1.2	91	6	80	41	28	59	32	....	....	....	2.46	−0.1	6	4,806	nw.	31	nw.	26	10	7	14	5.6	....	....

* Oct. 1-24 only.

TABLE I.—*Climatological data for Weather Bureau Stations, October, 1918*—**Continued.**

Districts and stations.	Elevation of instruments: Barometer above sea level.	Elevation of instruments: Thermometer above ground.	Elevation of instruments: Anemometer above ground.	Pressure: Station, reduced to mean of 24 hours.	Pressure: Sea level, reduced to mean of 24 hours.	Pressure: Departure from normal.	Temperature of the air: Mean max.+mean min.÷2.	Temperature of the air: Departure from normal.	Temperature of the air: Maximum.	Temperature of the air: Date.	Temperature of the air: Mean maximum.	Temperature of the air: Minimum.	Temperature of the air: Date.	Temperature of the air: Mean minimum.	Temperature of the air: Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation: Total.	Precipitation: Departure from normal.	Precipitation: Days with .01 inch or more.	Wind: Total movement.	Wind: Prevailing direction.	Wind: Maximum velocity: Miles per hour.	Wind: Maximum velocity: Direction.	Wind: Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F*		*°F*	*°F.*		*°F*	*°F.*	*°F.*	*°F.*	%	*In.*	*In.*		*Miles*								*0-10*	*In.*	*In.*
Ohio Valley and Tennessee.							**60.7**	**+3.8**										**74**	**3.32**	**+0.8**										**6.0**		
Chattanooga	762	189	213	29.28	30.10	+.01	64.7	+3.9	88	6	73	46	31	57	28	57	53	72	6.82	+4.0	13	5,077	ne.	31	nw.	31	8	11	12	6.1	....	....
Knoxville	996	102	111	29.04	30.09	.00	63.7	+5.6	86	6	72	44	31	55	29	57	53	76	5.19	+2.6	10	3,663	ne.	22	w.	24	7	13	11	5.9	T.	....
Memphis	399	76	97	29.64	30.06	−.01	66.6	+4.1	88	6	74	43	28	59	26	60	56	75	2.57	−0.2	10	4,617	e.	36	sw.	27	12	5	14	5.5	....	....
Nashville	546	168	191	29.50	30.08	.00	64.0	+3.7	87	6	73	42	31	55	32	57	53	74	3.44	+1.0	14	6,146	ne.	45	se.	27	10	6	15	5.9	....	....
Lexington	989	193	230	29.03	30.09	+.01	61.1	+4.6	84	5	70	38	31	52	35	....	....	....	4.57	+2.4	12	9,479	sw.	40	s.	27	6	11	14	6.3	....	....
Louisville	525	219	255	29.51	30.09	+.01	61.7	+3.3	86	5	71	41	31	53	30	54	50	70	2.62	0.0	10	7,612	s.	40	se.	27	9	9	13	5.6	....	....
Evansville	431	139	175	29.60	30.07	−.01	62.4	+4.4	85	5	72	41	31	53	30	55	51	72	2.49	−0.6	9	7,494	sw.	44	s.	27	9	13	9	5.3	....	....
Indianapolis	822	194	230	29.18	30.07	.00	58.3	+3.3	84	5	66	37	31	50	26	52	48	75	2.75	0.0	10	8,812	s.	44	s.	27	7	8	16	6.7	....	....
Terre Haute	575	96	129	29.43	30.04	......	59.1	......	86	5	68	38	31	50	27	52	48	74	2.56	......	6	6,830	s.	44	s.	27	9	12	10	5.6	....	....
Cincinnati	628	11	51	29.41	30.09	+.01	59.0	+0.6	85	5	69	38	29	49	32	52	48	74	2.68	+0.4	10	4,813	ne.	31	se.	27	9	6	16	6.3	....	....
Columbus	824	173	222	29.22	30.09	+.01	58.0	+3.9	83	5	68	39	31	49	28	51	46	71	2.09	−0.3	11	7,804	se.	42	nw.	5	11	9	11	5.5	....	....
Dayton	899	181	216	29.10	30.06	......	58.5	+4.4	83	5	68	37	31	49	29	52	48	75	1.64	−0.8	9	6,834	sw.	39	s.	27	8	13	10	6.0	....	....
Pittsburgh	842	353	410	29.20	30.11	+.03	58.2	+3.3	78	5	67	38	1	49	27	51	46	71	3.08	+0.7	10	7,370	sw.	43	nw.	5	7	10	14	6.6	....	....
Elkins	1,940	41	50	28.08	30.15	+.05	55.2	+3.8	79	17	68	27	22	42	44	48	45	80	3.40	+1.0	9	3,657	nw.	33	nw.	30	6	8	17	6.9	....	....
Parkersburg	638	77	84	29.46	30.11	+.03	59.2	+4.6	83	5	70	34	15	49	36	52	49	76	3.19	+0.8	11	3,211	se.	26	w.	6	11	8	12	5.5	....	....
Lower Lake Region.							**54.0**	**+2.2**										**75**	**2.97**	**0.0**										**6.0**		
Buffalo	767	247	280	29.24	30.07	+.02	53.4	+1.9	73	27	60	37	15	47	26	49	45	77	1.95	−1.6	10	11,532	sw.	54	sw.	5	10	5	16	6.5	....	....
Canton	448	10	61	29.59	30.07	......	48.0	+0.8	72	28	56	27	19	39	28	....	....	....	5.21	+1.9	15	7,369	sw.	40	ne.	17	8	9	14	5.9	....	....
Oswego	335	76	91	29.70	30.08	+.03	52.2	+1.0	75	27	60	33	8	45	30	47	44	77	3.78	+0.4	14	7,516	s.	39	ne.	17	6	8	17	6.5	....	....
Rochester	523	97	113	29.52	30.09	+.04	53.2	+2.4	75	27	62	34	22	45	34	47	43	76	3.28	+0.4	14	5,339	sw.	30	sw.	5	7	10	14	6.3	....	....
Syracuse	597	97	113	29.46	30.11	+.05	53.2	+2.2	75	27	61	33	19	45	28	....	....	....	3.56	+0.4	13	7,829	s.	40	s.	20	8	9	14	6.0	....	....
Erie	714	130	166	29.30	30.07	+.02	54.8	+1.7	76	5	63	36	19	47	29	49	45	73	3.85	0.0	12	10,635	s.	48	s.	20	9	10	12	5.7	....	....
Cleveland	762	190	201	29.26	30.08	+.02	56.0	+2.9	76	5	64	38	19	48	27	50	45	71	2.11	−0.6	10	9,619	s.	35	se.	28	10	9	12	6.0	....	....
Sandusky	629	62	103	29.39	30.08	+.02	56.0	+2.1	79	5	64	38	19	48	28	....	....	....	1.13	−1.3	9	8,854	sw.	42	ne.	18	9	7	15	6.4	....	....
Toledo	628	208	243	29.30	30.08	+.03	55.7	+3.1	76	5	64	38	31	48	31	50	46	76	2.99	+0.7	13	9,954	sw.	44	s.	27	13	4	14	5.5	....	....
Fort Wayne	856	113	124	29.15	30.08	......	55.4	+1.7	76	4	64	35	1	47	32	49	45	76	2.60	......	8	6,535	sw.	31	ne.	18	6	12	13	6.0	....	....
Detroit	730	218	245	29.28	30.08	+.03	55.6	+3.9	75	5	64	37	31	48	27	49	46	77	1.87	−0.5	11	8,486	sw.	45	sw.	5	9	14	8	5.6	....	....
Upper Lake Region.							**50.6**	**+2.9**										**79**	**3.17**	**+0.4**										**6.3**		
Alpena	609	13	92	29.37	30.04	+.01	48.8	+2.9	78	5	56	31	1	41	29	45	42	83	3.73	+0.3	13	8,582	se.	38	s.	27	5	11	15	6.7	....	....
Escanaba	612	54	60	29.35	30.02	+.01	48.0	+2.9	81	12	55	31	31	41	28	49	42	85	3.20	+0.1	11	7,828	s.	37	ne.	17	12	4	15	5.7	T.	....
Grand Haven	632	54	92	29.35	30.04	+.01	52.0	+1.8	70	11	60	33	31	44	30	48	45	80	4.42	+1.9	11	8,513	s.	40	sw.	28	8	8	15	5.9	T.	T.
Grand Rapids	707	70	87	29.28	30.06	+.02	53.8	+3.7	78	5	63	34	1	45	35	47	43	73	3.59	+1.0	11	4,434	s.	27	nw.	20	7	7	17	6.7	....	....
Houghton	684	62	99	29.26	29.99	−.01	46.2	+1.1	78	12	53	30	31	40	26	....	....	87	3.95	+0.8	16	6,963	e.	44	e.	27	8	5	18	7.0	2.4	1.0
Lansing	878	11	62	29.11	30.06	......	52.6	+3.9	77	17	63	29	1	42	38	46	43	81	3.21	+1.0	14	4,714	sw.	22	ne.	18	7	13	11	6.1	....	....
Ludington	637	60	66	29.33	30.03	......	50.4	......	71	11	58	34	18	43	25	46	43	77	2.84	......	11	8,112	s.	46	sw.	28	8	11	12	5.7	T.	....
Marquette	734	77	111	29.22	30.04	+.03	47.8	+1.7	82	12	55	31	31	41	28	43	39	77	3.91	+0.7	13	7,835	w.	33	nw.	20	3	14	14	7.0	0.3	0.2
Port Huron	638	70	120	29.36	30.05	+.01	53.1	+3.6	75	5	61	34	31	45	28	48	45	81	1.45	−1.3	12	8,355	sw.	36	ne.	17	5	16	10	5.9	....	....
Saginaw	641	48	82	29.35	30.05	......	53.0	......	79	5	63	32	31	43	36	46	42	77	2.75	0.0	10	7,215	s.	33	sw.	28	8	11	12	5.7	....	....
Sault Ste. Marie	614	11	61	29.34	30.04	+.03	46.2	+2.8	70	10	53	30	1	39	32	42	40	84	4.38	+1.1	20	6,706	e.	38	w.	20	5	9	17	7.3	....	....
Chicago	823	140	310	29.16	30.05	+.01	57.4	+4.2	80	5	64	37	31	51	26	51	47	71	2.94	+0.4	9	8,936	nw.	36	ne.	18	9	11	11	5.5	T.	....
Green Bay	617	109	144	29.34	30.01	−.01	51.3	+4.2	82	12	60	32	31	43	29	45	41	74	2.18	−0.2	8	8,731	sw.	42	s.	28	10	7	14	6.6	....	....
Milwaukee	681	119	133	29.29	30.03	.00	54.8	+4.6	81	15	62	35	31	45	33	48	44	74	2.42	0.0	8	8,306	sw.	39	e.	27	11	7	13	5.7	....	....
Duluth	1,133	11	47	28.77	30.00	−.02	45.4	+0.2	76	12	52	26	31	39	29	40	37	80	2.18	−0.6	12	10,210	ne.	65	w.	12	9	4	18	6.6	0.1	....
North Dakota.							**46.6**	**+4.0**										**69**	**0.68**	**−0.6**										**5.1**		
Moorhead	940	8	57	29.00	30.03	+.03	47.6	+4.8	80	11	58	24	31	37	43	41	37	75	1.51	−0.6	10	6,817	nw.	39	nw.	12	14	7	10	4.9	....	....
Bismarck	1,674	8	57	28.26	30.06	+.07	47.5	+3.4	80	14	60	13	28	35	48	40	33	65	0.28	−0.8	3	6,855	nw.	35	nw.	12	13	8	10	4.6	T.	....
Devils Lake	1,482	11	44	28.41	30.01	+.02	44.4	+3.9	74	11	55	20	27	34	37	37	32	72	0.55	−0.7	7	7,394	nw.	40	nw.	12	12	8	11	5.3	2.0	....
Ellendale	1,457	10	56	28.45	30.03	......	47.6	......	80	4	60	17	27	35	43	40	33	66	0.23	......	4	9,985	nw.	48	s.	21	11	11	9	5.3	T.	....
Grand Forks	835	12	89	......	......	......	......	......	....	....	....	....	....	....	....	....	....	....	......	......	....	......	......	....	......	....	....	....	....	....	......	....
Williston	1,872	41	48	27.99	29.99	+.01	46.7	+3.8	76	11	58	13	31	35	42	39	32	63	0.38	−0.4	6	6,088	se.	36	nw.	12	11	10	10	5.5	0.2	....
Upper Mississippi Valley.							**56.1**	**+3.3**										**74**	**2.77**	**+0.3**										**5.8**		
Minneapolis	918	10	208	29.00	29.99	......	50.9	......	81	16	59	28	31	43	30	....	....	....	2.31	−0.3	11	8,828	s.	38	nw.	12	5	9	17	7.0	T.	....
St. Paul	837	201	236	29.09	30.00	−.01	50.2	+2.1	79	12	58	27	31	42	29	....	....	81	2.61	+0.3	12	9,275	se.	39	nw.	12	10	5	16	6.5	2.7	....
La Crosse	714	11	48	29.23	30.01	−.01	51.8	+1.9	86	12	62	30	31	42	38	....	....	....	1.57	−0.9	9	3,978	s.	20	nw.	12	8	7	16	6.2	T.	....
Madison	974	70	78	28.99	30.04	+.01	52.9	+4.1	78	5	62	32	31	44	33	46	41	72	3.13	+0.7	10	7,140	sw.	40	ne.	17	13	4	14	5.8	T.	....
Wausau	1,247	4	....	28.67	30.01	......	47.6	......	78	12	57	27	3	38	34	....	....	....	1.69	......	10	......	se.	....	......	....	13	4	14	5.5	T.	....
Charles City	1,015	10	49	28.94	30.02	.00	51.6	+3.4	84	12	62	26	31	42	35	45	42	78	3.13	+1.1	7	4,872	nw.	24	se.	7	12	7	12	5.6	T.	....
Davenport	606	71	79	29.38	30.04	.00	56.1	+3.5	83	16	66	33	25	46	32	49	44	73	2.45	+0.1	10	5,663	e.	30	sw.	27	12	6	13	5.5	T.	....
Des Moines	861	84	97	29.10	30.01	−.02	56.6	+4.1	86	16	66	30	31	47	34	49	44	70	3.81	+1.1	9	5,410	sw.	36	sw.	4	8	9	14	6.0	T.	....
Dubuque	698	81	96	29.29	30.05	+.01	54.0	+2.0	82	15	64	32	25	44	34	47	42	72	2.85	+0.2	9	4,558	s.	28	s.	27	11	8	12	5.5	T.	....
Keokuk	614	64	78	29.37	30.04	−.01	58.3	+3.8	85	5	68	35	31	49	30	50	46	71	2.16	−0.3	9	5,368	s.	37	s.	27	14	6	11	5.5	......	....
Cairo	356	87	93	29.64	30.03	−.04	62.8	+3.7	87	5	71	42	31	54	27	57	53	79	3.07	+0.4	10	5,205	ne.	36	se.	27	7	9	15	6.2	......	....
Peoria	609	11	45	29.39	30.05	.00	56.2	+4.2	82	5	67	33	30	46	32	50	46	79	2.97	+0.4	9	4,830	s.	28	sw.	28	12	9	10	5.0	......	....
Springfield, Ill	644	10	91	29.36	30.04	−.01	58.4	+3.8	86	5	67	35	31	50	27	51	48	76	2.79	+0.2	7	5,813	s.	33	se.	27	9	7	15	6.0	......	....
Hannibal	534	74	109	29.46	30.03	−.02	58.6	+2.7	85	5	68	35	31	49	30	....	....	....	2.25	+0.6	8	6,135	sw.	40	s.	27	10	7	14	5.8	T.	....
St. Louis	567	265	303	29.43	30.03	−.03	62.3	+3.9	88	5	70	41	31	54	25	54	49	68	3.63	+1.2	6	8,766	s.	66	sw.	27	15	4	12	4.5	......	....
Missouri Valley.							**57.0**	**+ 4.4**										**70**	**2.82**	**+ 0.9**										**5.1**		
Columbia, Mo.	781	11	84	29.19	30.02	− .03	60.1	+ 5.3	88	5	70	34	31	50	32	....	....	....	1.99	− 0.4	6	5,337	e.	36	sw.	27	10	8	13	5.7	......	....
Kansas City	963	161	181	28.98	30.02	− .02	61.4	+ 5.6	87	5	70	36	31	53	25	52	47	67	4.00	+ 1.8	9	7,610	s.	35	nw.	31	13	8	10	4.9	......	....
St. Joseph	967	11	49	28.98	30.02	......	60.1	......	88	4	70	34	31	51	35	51	46	68	3.10	......	11	5,548	e.	26	w.	27	15	8	8	4.3	......	....
Springfield, Mo.	1,324	98	104	28.63	30.03	− .02	61.6	+ 4.3	85	5	70	33	31	54	26	54	51	75	2.72	− 0.1	12	7,266	se.	32	sw.	27	11	8	12	5.7	T.	....
Iola	984	11	50	28.96	29.98	− .07	61.6	+ 4.7	91	6	72	31	31	51	34	....	....	....	5.08	+ 2.8	10	4,162	se.	27	n.	8	6	11	14	6.4	......	....
Topeka	983	85	101	......	......	......	60.6	+ 4.3	90	4	70	33	31	51	31	....	....	....	3.95	+ 2.0	9	6,374	e.	33	sw.	4	9	13	9	5.1	T.	....
Drexel	1,299	10	54	28.61	30.00	......	55.8	......	87	4	65	28	28	47	32	48	44	76	5.01	......	11	7,714	se.	35	sw.	14	9	8	14	6.2	......	....
Lincoln	1,189	11	84	28.74	30.00	− .03	58.1	+ 4.8	90	4	68	32	28	49	32	49	44	70	4.80	+ 3.0	12	6,495	s.	32	nw.	30	7	9	15	6.4	T.	....
Omaha	1,105	115	122	28.83	30.01	− .02	57.7	+ 3.5	88	4	66	31	28	49	28	49	44	69	4.65	+ 2.3	12	5,669	s.	30	n.	27	8	9	14	6.3	0.2	....
Valentine	2,598	47	54	27.32	30.04	+ .03	52.2	+ 3.7	89	14	66	19	31	39	41	44	40	72	0.79	− 0.5	8	6,080	nw.	34	nw.	30	11	12	8	5.0	3.1	....
Sioux City	1,135	94	164	28.81	30.03	+ .01	54.0	+ 2.9	87	12	63	28	28	45	35	46	41	71	2.65	+ 0.9	12	8,347	nw.	36	s.	14	9	9	13	5.9	5.5	....
Huron	1,306	59	74	28.64	30.06	+ .05	50.8	+ 6.1	86	16	63	24	29	39	43	42	36	67	1.34	0.0	8	7,559	nw.	40	sw.	6	11	11	9	5.0	0.3	....
Pierre	1,572	70	75	28.36	30.03	+ .02	53.4	+ 4.3	87	14	65	18	28	41	42	44	39	69	0.41	− 0.4	8	5,941	nw.	35	nw.	30	16	6	9	4.5	0.3	....
Yankton	1,233	49	57	28.69	30.01	.00	53.6	+ 3.1	87	14	64	24	28	43	37	....	....	....	1.46	− 0.1	8	4,917	se.	24	nw.	27	6	10	15	6.6	4.1	....

TABLE I.—*Climatological data for Weather Bureau Stations, October, 1918*—Continued.

Districts and stations.	Elevation of instruments: Barometer above sea level.	Elevation: Thermometer above ground.	Elevation: Anemometer above ground.	Pressure: Station, reduced to mean of 24 hours.	Pressure: Sea level, reduced to mean of 24 hours.	Pressure: Departure from normal.	Temperature: Mean max.+mean min.÷2.	Temperature: Departure from normal.	Temperature: Maximum.	Temperature: Date.	Temperature: Mean maximum.	Temperature: Minimum.	Temperature: Date.	Temperature: Mean minimum.	Temperature: Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation: Total.	Precipitation: Departure from normal.	Precipitation: Days with .01 inch or more.	Wind: Total movement.	Wind: Prevailing direction.	Wind: Maximum velocity: Miles per hour.	Wind: Maximum velocity: Direction.	Wind: Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles								0–10	In.	In.
Northern Slope.							**49.4**	**+ 4.8**										**68**	**0.86**	**− 0.1**										**5.2**		
Billings	3,140	5	...	...	...	...	51.2	...	83	13	66	18	26	36	47	...	...	...	0.42	...	6	...	...	...	...	...	16	9	6	...	...	...
Havre	2,505	11	44	27.33	29.97	− .01	48.9	+ 5.3	80	13	62	21	23	36	44	43	38	74	1.05	+ 0.6	6	5,234	sw.	40	sw.	11	10	8	13	5.9	...	...
Helena	4,110	87	114	25.82	30.03	.00	49.9	+ 5.9	79	13	59	31	23	40	34	41	33	58	0.39	− 0.4	9	6,099	sw.	36	sw.	28	10	11	10	5.4	T.	...
Kalispell	2,962	11	34	26.96	30.02	+ .01	47.0	+ 4.5	72	12	56	26	22	38	31	42	37	73	0.91	− 0.3	11	3,594	nw.	24	nw.	29	5	9	17	7.0	T.	...
Miles City	2,371	26	48	27.48	30.05	+ .05	52.4	+ 5.9	81	13	64	25	31	40	38	45	42	77	0.35	− 0.4	6	3,659	se.	26	sw.	28	13	13	5	3.9	T.	...
Rapid City	3,259	50	58	26.64	30.06	+ .05	51.8	+ 5.2	83	14	64	23	31	40	38	43	34	57	0.29	− 0.8	5	5,807	w.	36	nw.	30	14	7	10	4.9	T.	...
Cheyenne	6,088	84	101	24.06	30.03	+ .02	48.2	+ 2.9	74	6	59	16	27	37	37	40	35	67	0.68	0.0	8	8,130	w.	44	w.	4	9	12	10	5.8	0.2	...
Lander	5,372	60	68	24.69	30.06	+ .02	48.8	+ 6.7	79	13	64	19	27	34	44	38	29	54	0.40	− 0.6	3	3,046	sw.	26	n.	28	11	17	3	4.8	T.	...
Sheridan	3,790	10	47	26.14	30.06	...	48.5	...	81	14	64	19	26	33	45	40	36	74	0.51	...	6	3,304	s.	38	nw.	28	15	5	11	4.8	T.	
Yellowstone Park	6,200	11	48	...	30.09	...	43.6	+ 2.1	69	12	54	17	26	33	32	...	...	71	2.27	+ 1.1	16	4,610	s.	24	s.	15	9	12	10	4.8	...	
North Platte	2,821	11	51	27.13	30.06	+ .04	54.4	+ 4.4	89	6	68	21	31	41	44	46	41	73	1.42	+ 0.3	10	4,619	n.	25	nw.	30	14	4	13	4.9	2.3	...
Middle Slope.							**59.4**	**+ 3.8**										**69**	**3.00**	**+ 1.5**										**5.4**		
Denver	5,292	106	113	24.78	30.03	+ .02	54.6	+ 3.6	82	14	66	25	27	43	41	45	38	62	0.42	− 0.5	8	4,584	s.	28	n.	28	9	8	14	6.0	T.	...
Pueblo	4,685	80	86	25.34	30.01	+ .02	55.8	+ 3.5	87	4	70	25	27	42	46	44	36	57	0.14	− 0.6	5	3,549	nw.	30	nw.	27	13	8	10	5.0	...	...
Concordia	1,392	50	58	28.55	30.02	− .01	59.6	+ 4.2	92	6	69	31	28	50	37	51	46	72	4.49	+ 2.5	9	5,753	s.	34	nw.	7	7	11	13	6.3	2.2	...
Dodge City	2,509	11	51	27.41	30.01	− .01	59.8	+ 5.1	88	3	71	28	27	49	41	50	46	72	1.67	+ 0.3	8	7,103	se.	33	w.	4	11	9	11	4.9	...	...
Wichita	1,358	139	158	28.56	29.99	− .04	61.4	+ 2.6	89	4	70	32	31	53	27	54	50	75	5.98	+ 3.7	12	8,427	s.	47	sw.	4	7	14	10	5.5	...	...
Altus	1,410	5	...	...	...	...	66.0	...	95	5	77	32	27	55	37	...	...	...	8.63	...	7	...	n.	...	...	...	17	2	12	...	...	...
Muskogee	652	4	...	...	...	...	65.9	...	90	2	76	39	28	56	35	...	...	...	5.73	...	9	...	s.	...	...	...	6	4	21	...	...	...
Oklahoma	1,214	10	47	28.73	30.00	− .03	65.2	+ 3.9	89	7	75	34	27	55	31	56	53	76	5.31	+ 3.5	8	7,534	s.	38	n.	26	13	7	11	4.9	...	...
Southern Slope.							**64.6**	**+ 2.2**										**65**	**3.04**	**+ 0.5**										**3.9**		
Abilene	1,738	10	52	28.19	29.99	− .02	67.2	+ 3.0	93	8	78	39	27	56	32	56	50	67	3.66	+ 1.3	7	5,840	s.	37	sw.	28	15	7	9	4.4	...	...
Amarillo	3,676	10	49	26.30	30.00	.00	60.0	+ 3.9	92	7	72	26	27	48	36	49	43	66	2.47	− 1.8	11	7,567	s.	37	n.	26	14	8	9	4.7	4.4	...
Del Rio	944	64	71	28.99	29.97	− .01	70.6	+ 0.7	93	7	81	44	27	60	32	...	...	...	5.24	+ 3.2	6	5,193	se.	47	nw.	26	18	8	5	3.2	...	...
Roswell	3,566	75	85	26.38	29.97	+ .01	60.8	+ 1.3	90	6	75	33	26	47	43	50	44	62	0.79	− 0.7	6	4,966	s.	35	nw.	28	17	10	4	3.2	...	...
Southern Plateau.							**61.7**	**+ 1.9**										**52**	**1.00**	**+ 0.4**										**2.7**		
El Paso	3,762	110	133	26.19	29.92	.00	64.6	+ 2.2	90	2	77	35	27	52	37	50	39	46	1.03	+ 0.1	6	6,609	se.	49	w.	28	20	5	6	3.1	...	...
Santa Fe	7,013	57	66	23.31	29.98	+ .02	52.0	+ 2.0	77	3	62	25	26	42	27	41	32	59	2.73	+ 1.7	10	4,682	e.	32	sw.	20	14	13	4	4.1	0.5	...
Flagstaff	6,908	8	57	23.40	29.96	+ .04	47.8	+ 3.1	76	1	63	16	27	33	44	39	...	...	0.51	...	4	...	sw.	37	nw.	28	22	8	1	...	...	...
Phoenix	1,108	76	81	28.73	29.87	− .01	71.8	+ 1.6	99	13	87	39	27	56	44	58	50	56	0.52	+ 0.2	2	3,416	e.	29	nw.	25	21	8	2	2.2	...	...
Yuma	141	9	54	29.72	29.86	− .01	74.0	+ 1.6	101	1	88	47	27	60	37	60	51	54	0.35	+ 0.2	2	2,907	n.	27	s.	19	28	2	1	1.2	...	...
Independence	3,910	11	42	26.01	30.04	+ .09	60.1	+ 0.8	84	11	74	32	26	46	36	47	35	46	0.35	0.0	2	3,994	nw.	27	nw.	25	19	10	2	2.7	...	...
Needles	488	4	...	29.38	29.89	...	73.5	...	102	1	89	40	27	58	47	...	...	...	0.13	...	2	...	...	...	...	...	21	4	6	...	...	...
Middle Plateau.							**53.6**	**+2.8**										**59**	**0.74**	**−0.1**										**4.2**		
Reno	4,532	74	81	25.54	30.05	+.06	53.6	+3.9	82	12	68	27	26	39	40	44	36	60	0.75	+0.3	6	3,385	w.	29	w.	13	20	5	6	3.2	...	...
Tonopah	6,090	12	20	24.12	30.00	...	52.8	...	74	12	62	30	25	44	23	42	49	51	0.52	−0.3	4	6,876	se.	42	nw.	28	19	11	1	2.6	0.5	...
Winnemucca	4,344	18	56	25.70	30.10	+.05	51.6	+3.0	83	12	66	22	26	37	46	43	36	64	0.45	−0.1	7	3,763	ne.	30	s.	14	15	8	8	4.1	...	...
Modena	5,479	10	43	24.67	30.01	+.05	51.1	+1.0	77	13	65	21	27	37	48	41	32	55	0.69	−0.1	7	6,976	w.	34	n.	28	10	10	11	4.9	...	...
Salt Lake City	4,360	163	203	25.67	30.03	+.02	55.0	+2.8	79	13	64	31	27	46	29	47	41	64	1.13	−0.3	9	5,045	se.	42	s.	3	10	13	8	5.1	T.	...
Grand Junction	4,602	82	96	25.94	30.02	+.03	56.6	+3.3	80	2	68	28	27	46	30	46	38	58	0.87	0.0	5	3,713	se.	39	se.	17	8	14	9	5.2	T.	...
Northern Plateau.							**53.3**	**+3.9**										**67**	**1.52**	**+0.3**										**5.7**		
Baker	3,471	48	53	26.51	30.11	+.03	49.2	+3.7	78	12	60	26	23	38	36	43	39	72	0.71	−0.2	7	4,278	se.	20	n.	17	14	11	6	4.4	...	...
Boise	2,739	78	86	27.24	30.11	+.05	53.6	+3.3	85	13	64	30	23	43	34	46	40	64	1.98	+0.7	8	2,989	se.	25	w.	24	13	11	7	4.5	...	...
Lewiston	757	40	48	29.26	30.07	.00	56.5	+4.7	87	1	67	35	22	46	38	...	...	...	2.27	+1.1	13	1,723	e.	21	w.	28	6	9	16	6.7	...	...
Pocatello	4,477	60	68	25.54	30.08	+.04	51.1	+3.1	80	12	61	29	26	41	34	43	37	66	1.29	+0.3	7	6,216	se.	37	sw.	27	10	13	8	5.5	T.	...
Spokane	1,929	101	110	28.00	30.05	−.01	52.4	+5.1	77	2	62	30	30	43	31	46	41	68	1.31	−0.2	9	4,535	sw.	31	sw.	11	0	15	16	7.5	...	...
Walla Walla	991	57	65	29.00	30.07	.00	57.0	+3.3	82	11	66	36	30	48	27	50	44	64	1.53	+0.1	14	3,421	s.	33	sw.	27	11	10	10	5.5	...	...
North Pacific Coast Region.							**54.1**	**+2.4**										**85**	**4.51**	**+0.7**										**7.1**		
North Head	211	11	58	29.85	30.08	+.03	53.2	+0.3	63	4	56	45	22	50	12	52	51	94	4.34	+0.4	19	11,069	se.	72	se.	4	2	4	25	8.2	...	...
North Yakima	1,071	4	...	...	...	...	52.4	...	81	2	66	29	30	39	36	...	...	...	1.14	...	7	...	nw.	...	...	...	14	13	4	...	...	...
Port Angeles	29	8	53	30.05	30.08	...	49.1	...	62	19	56	37	14	43	20	...	...	...	3.15	+0.6	16	3,567	s.	37	sw.	27	4	4	23	7.8	...	...
Seattle	125	215	250	29.96	30.09	+.04	53.4	+2.6	68	4	58	39	22	48	22	51	48	85	3.46	+0.6	15	6,612	s.	46	sw.	27	0	10	21	8.3	...	...
Tacoma	213	113	120	29.86	30.09	+.05	53.2	+2.6	66	3	59	36	22	47	25	50	48	83	4.93	+1.5	17	4,323	sw.	31	sw.	27	1	10	20	7.8	...	...
Tatoosh Island	109	7	57	29.94	30.04	+.03	51.8	+1.9	60	4	55	44	14	49	11	50	49	91	10.07	+2.1	23	11,178	s.	68	s.	27	7	9	15	6.7	...	...
Medford	1,425	4	...	...	...	...	55.2	...	84	1	69	27	23	42	42	...	...	...	1.57	...	7	...	se.	...	...	...	13	8	10	...	...	...
Portland, Oreg.	153	68	106	29.93	30.08	+.02	56.4	+3.1	78	11	64	38	22	49	24	53	50	80	4.47	+0.8	16	3,968	nw.	29	s.	27	4	15	12	6.2	...	...
Roseburg	510	9	57	29.56	30.12	+.04	56.4	+3.6	83	1	67	34	28	46	37	51	48	76	1.18	−1.4	13	1,630	n.	16	sw.	27	11	16	4	4.6	...	...
Middle Pacific Coast Region.							**61.1**	**+2.4**										**69**	**0.45**	**−1.1**										**3.6**		
Eureka	62	73	89	30.04	30.11	+.05	54.2	+1.1	69	19	60	43	25	49	22	52	50	88	1.00	−1.6	9	3,705	n.	29	n.	18	6	11	14	6.4	...	...
Mount Tamalpais	2,375	11	18	27.58	30.04	+.03	60.8	+2.1	82	12	67	44	22	54	23	50	41	55	0.45	−1.5	4	10,383	nw.	50	s.	14	18	7	6	3.4	...	...
Point Reyes Light	490	7	18	29.48	30.00	...	57.4	+2.7	79	12	62	50	22	53	23	...	...	88	0.69	...	5	12,923	nw.	46	nw.	17	12	11	8	5.0	...	...
Red Bluff	332	50	56	29.65	30.00	−.03	65.2	+1.4	86	13	77	43	26	54	32	56	48	57	0.51	−1.1	5	3,799	nw.	29	nw.	18	22	6	3	2.6	...	...
Sacramento	69	106	117	29.93	30.00	+.01	64.2	+2.0	88	19	76	44	24	52	33	56	48	62	0.40	−0.6	2	5,094	se.	33	n.	18	21	8	2	2.3	...	...
San Francisco	155	209	213	29.85	30.02	+.01	64.0	+5.6	85	12	72	52	24	56	24	56	52	74	0.17	−1.1	5	4,678	sw.	30	ne.	19	21	6	4	2.2	...	...
San Jose	141	12	110	29.87	30.02	...	62.0	+1.7	89	12	75	38	18	49	38	...	...	59	0.15	−0.8	5	3,371	nw.	24	n.	18	18	7	6	3.3	...	...
South Pacific Coast Region.							**68.4**	**+6.0**										**64**	**0.34**	**−0.5**										**3.0**		
Fresno	327	89	98	29.63	29.99	+.03	66.7	+2.0	94	13	79	45	25	54	34	56	48	56	0.11	−0.6	2	4,394	nw.	28	sw.	1	24	4	3	2.1	...	...
Los Angeles	338	159	191	29.58	29.94	−.01	71.0	+8.7	98	11	81	52	24	62	37	60	54	65	T.	−0.8	0	3,858	ne.	19	ne.	18	19	8	4	3.0	...	...
San Diego	87	62	70	29.84	29.93	−.02	68.1	+5.1	90	31	75	54	18	61	27	61	57	74	0.42	0.0	5	4,172	nw.	22	s.	19	18	5	8	4.1	...	...
San Luis Obispo	201	32	40	29.77	29.99	.00	67.6	+8.4	99	12	80	44	26	55	44	56	49	63	0.81	−0.5	3	3,060	nw.	22	ne.	1	19	8	4	2.9	...	...
West Indies.																																
San Juan, P. R.	82	8	54	29.84	29.92	...	79.4	...	89	22	85	71	24	74	17	...	...	...	7.77	+1.7	20	6,462	e.	34	e.	30	4	17	10	6.1	...	...
Panama Canal.																																
Balboa Heights	118	7	97	...	29.83	...	79.8	...	91	5	83	71	1	74	17	75	74	90	9.16	− 1.1	19	5,367	nw.	28	sw.	22	1	14	16	7.3	...	...
Colon	36	30	97	...	29.83	...	79.4	...	89	23	84	72	1	74	14	76	75	89	27.07	+12.2	25	5,676	w.	36	e.	1	1	5	25	8.5	...	...
Alaska.																																
Junean	80	11	49	...	...	...	42.4	...	58	10	46	28	25	38	17	40	38	88	13.96	...	30	3,512	se.	31	se.	30	0	0	31	9.8	9.5	...

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes or 0.80 in 1 hour, during October, 1918, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex.	26			1.25														0.72			
Albany, N. Y.	5			0.24														0.17			
Alpena, Mich.	4			0.71														0.20			
Amarillo, Tex.	21			1.43														*			
Anniston, Ala.	24	4:00 a.m.	12:50 p.m.	1.78	7:20 a.m.	8:32 a.m.	0.05	0.08	0.12	0.33	0.48	0.52	0.58	0.64	0.72	0.80	0.87	0.97	1.15		
	28-29	D. N. p.m	11:35 a.m.	2.53	6:12 a.m.	7:02 a.m.	0.46	0.13	0.16	0.23	0.27	0.35	0.43	0.49							
					7:02 a.m.	7:52 a.m.		0.79	0.89	0.97	1.03	1.10	1.15	1.27	0.61	0.66	0.71				
					7:52 a.m.	8:15 a.m.		1.52	1.62	1.67	1.80	1.88			1.37	1.42	1.46				
	29	12:30 p.m.	9:50 p.m.	1.55	1:08 p.m.	1:37 p.m.	0.02	0.12	0.20	0.30	0.43	0.51	0.60	0.64							
Asheville, N. C.	24-25	12:20 p.m.	10:00 a.m.	7.76	6:25 a.m.	7:55 a.m.	4.88	0.09	0.17	0.46	0.67	0.91	1.10	1.20	1.25	1.36	1.57	1.68	1.94	2.50	
Atlanta, Ga.	24	11:15 a.m.	3:50 p.m.	1.62	1:19 p.m.	1:45 p.m.	0.56	0.18	0.29	0.37	0.56	0.77	0.78								
	29	2:55 p.m.	4:46 p.m.	0.77	3:20 p.m.	3:40 p.m.	0.01	0.35	0.44	0.46	0.61										
Atlantic City, N. J.	31			0.65														0.32			
Augusta, Ga.	30			0.65														0.61			
Baker, Oreg.	15			0.26														0.18			
Baltimore, Md.	30			0.37														0.32			
Bentonville, Ark.	8	6:05 a.m.	10:15 a.m.	2.05	6:08 a.m.	7:58 a.m.	0.01	0.11	0.19	0.27	0.34	0.41	0.43	0.44	0.45	0.45	0.46	0.78	1.36	1.74	1.96
Binghamton, N. Y.	5			0.94														0.47			
Birmingham, Ala.	19	D.N. a.m.	10:35 a.m.	1.11	8:00 a.m.	8:26 a.m.	0.44	0.14	0.27	0.30	0.44	0.58	0.61								
	24	D.N. a.m.	9:15 a.m.	2.26	3:49 a.m.	4:19 a.m.	0.05	0.13	0.38	0.66	0.79	0.90	0.97								
	29-30	D.N. a.m.	9:19 a.m.	5.79	10:49 a.m.	12:47 p.m.	0.46	0.09	0.18	0.22	0.27	0.30	0.35	0.56	0.80	0.92	1.02	1.35	1.75	2.04	2.24
Bismarck, N. Dak.	23			0.25														0.06			
Block Island, R. I.	31			0.26														0.08			
Boise, Idaho	3			0.40														0.38			
Boston, Mass.	6			0.25														0.15			
Buffalo, N. Y.	20			0.71														0.18			
Burlington, Vt.	29-30	D. N. p.m	7:30 a.m.	1.18	10:00 p.m	10:34 p.m	0.03	0.07	0.21	0.35	0.41	0.54	0.63	0.69							
Cairo, Ill.	11			0.62														0.37			
Canton, N. Y.	17			0.41														0.29			
Charles City, Iowa	27			1.85														0.32			
Charleston, S. C.	21			1.03														0.38			
Charlotte, N. C.	20			1.30														0.40			
Chattanooga, Tenn.	24			1.47														0.67			
Cheyenne, Wyo.	2			0.19														0.12			
Chicago, Ill.	24			1.63														0.20			
Cincinnati, Ohio	30			0.47														0.25			
Cleveland, Ohio	12			0.70														0.23			
Columbia, Mo.	27			0.72														0.37			
Columbia, S. C.	20			0.93														0.39			
Columbus, Ohio	5			0.64														0.49			
Concord, N. H.	6			0.52														0.16			
Concordia, Kans.	7			0.48														0.47			
Corpus Christi, Tex.	11	9:04 a.m.	12:50 p.m.	1.93	10:21 a.m.	10:42 a.m.	0.43	0.23	0.46	0.76	1.03	1.08									
	12	3:20 a.m.	10:45 a.m.	2.25	7:19 a.m.	8:06 a.m.	0.68	0.11	0.27	0.40	0.58	0.81	0.97	1.08	1.18	1.26	1.31				
Dallas, Tex.	26	8:04 a.m.	6:09 p.m.	2.66	9:37 a.m.	11:14 a.m.	0.06	0.10	0.12	0.22	0.35	0.54	0.68	0.74	0.84	1.11	1.33	1.46	1.90	2.12	
Davenport, Iowa	27			1.51														0.53			
Dayton, Ohio	28			0.46														0.27			
Del Rio, Tex.	21-22	6:50 a.m.	1:50 a.m.	4.16	10:36 a.m.	12:36 p.m.	0.59	0.11	0.22	0.33	0.41	0.62	0.74	0.81	0.86	0.89	0.92	1.03	1.34	1.85	2.22
Denver, Colo.	24			0.27														0.13			
Des Moines, Iowa	27			1.65														0.42			
Detroit, Mich.	20			1.09														0.39			
Devils Lake, N. Dak.	18			0.13														0.09			
Dodge City, Kans.	25			0.81														*			
Drexel, Nebr.	10			1.51														0.51			
Dubuque, Iowa	27			1.46														0.36			
Duluth, Minn.	23-24			0.27														0.14			
Eastport, Me.	31			0.71														0.29			
Elkins, W. Va.	30			1.07														0.29			
Ellendale, N. Dak.	22			0.09														0.07			
El Paso, Tex.	18			0.35														0.16			
Erie, Pa.	2			0.73														0.29			
Escanaba, Mich.	27			1.44														0.50			
Eureka, Cal.	16			0.13														0.10			
Evansville, Ind.	19			0.76														0.23			
Flagstaff, Ariz.	19			0.28														*			
Fort Smith, Ark.	26-27	2:15 p.m.	D. N. a.m.	1.34	2:19 p.m.	3:06 p.m.	0.01	0.14	0.25	0.35	0.44	0.50	0.55	0.56	0.59	0.72	0.76				
Fort Wayne, Ind.	27			0.79														0.48			
Fort Worth, Tex.	22			1.45														0.53			
Fresno, Cal.	1			0.10														0.04			
Galveston, Tex.	22			0.64														0.47			
Grand Haven, Mich.	27			0.93														0.52			
Grand Junction, Colo.	9			0.45														0.17			
Grand Rapids, Mich.	27			0.82														0.33			
Green Bay, Wis.	27			1.56														0.31			
Greenville, S. C.	24-25	2:40 p.m.	4:20 p.m.	7.34	7:05 p.m.	7:55 p.m.	0.43	0.09	0.17	0.32	0.44	0.61	0.72	0.78	0.82	0.86	0.91				
					7:55 p.m.	8:45 p.m.		0.96	0.99	1.02	1.07	1.13	1.20	1.26	1.32	1.36	1.37				
					8:45 p.m.	9:07 p.m.		1.42	1.47	1.56	1.63	1.67									
					1:19 p.m.	2:23 p.m.	4.93	0.13	0.42	0.62	0.68	0.74	0.80	0.89	0.95	1.02	1.15	1.50	1.57		
	29	D.N. a.m.	2:00 p.m.	1.15	8:38 a.m.	9:19 a.m.	0.29	0.10	0.15	0.34	0.36	0.37	0.52	0.58	0.64	0.67					
Hannibal, Mo.	27			0.92														0.47			
Harrisburg, Pa.	30-31	7:28 p.m.	D. N. a.m.	0.84	8:17 p.m.	8:47 p.m.	0.15	0.08	0.19	0.32	0.41	0.45	0.56								
Hartford, Conn.	3			0.19														0.15			
Hatteras, N. C.	2			0.54														*			
Havre, Mont.	17			0.72														0.23			
Helena, Mont.	15			0.18														0.09			
Houghton, Mich.	5			1.04														0.23			
Houston, Tex.	4	12:18 p.m.	9:15 p.m.	4.92	1:11 p.m.	2:20 p.m.	0.04	0.14	0.23	0.27	0.35	0.46	0.70	0.91	1.13	1.44	1.81	2.78	3.48		
					4:06 p.m.	4:25 p.m.	4.06	0.20	0.40	0.56	0.63										
	22	6:31 a.m.	D. N. p.m.	1.34	2:53 p.m.	3:31 p.m.	0.23	0.10	0.15	0.21	0.35	0.57	0.76	0.86	0.92						
Huron, S. Dak.	22			0.59														0.33			
Independence, Cal.	16			0.34														0.12			
Indianapolis, Ind.	27			0.56														0.56			
Iola, Kans.	27			0.68														0.47			
Jacksonville, Fla.	16-17	6:35 a.m.	D. N. a.m.	1.35	12:14 a.m.	12:36 a.m.	0.48	0.23	0.43	0.61	0.72	0.82									
Kalispell, Mont.	14			0.17														0.10			
Kansas City, Mo.	26-27	1:32 p.m.	D. N. a.m.	2.70	9:41 p.m.	10:20 p.m.	1.74	0.05	0.11	0.22	0.33	0.50	0.71	0.78	0.86						
Keokuk, Iowa	27			0.56														0.19			
Key West, Fla.	14-15	D. N. p.m.	D. N. a.m.	1.60	12:34 a.m.	12:59 a.m.	0.44	0.10	0.34	0.58	0.78	0.98									
	24	1:23 p.m.	3:10 p.m.	0.88	2:31 p.m.	2:46 p.m.	0.32	0.17	0.34	0.51											

* Self-register not in use.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes or 0.80 in 1 hour, during October, 1918, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Knoxville, Tenn	29			1.84														0.48			
La Crosse, Wis	27			1.17														0.37			
Lander, Wyo	17			0.36														0.26			
Lansing, Mich	27			0.84														0.35			
Lewiston, Idaho	13			0.53														0.52			
Lexington, Ky	28			0.90														0.45			
Lincoln, Nebr	10			0.53														0.29			
Little Rock, Ark	26			1.13														0.52			
Los Angeles, Cal	3-14-15			T.														T.			
Louisville, Ky	19			0.95														0.48			
Ludington, Mich	27			0.75														0:30			
Lynchburg, Va	0.30			0.34														0.20			
Macon, Ga	25	6:12 a. m.	12:20 p. m.	2.04	7:46 a. m.	8:27 a. m.	0.28	0.14	0.26	0.57	0.65	0.68	0.84	0.87	0.93	0.96					
Madison, Wis	26-27	9:00 p. m.	1:40 p. m.	1.92	12:38 p. m.	1:29 p. m.	1.08	0.32	0.40	0.44	0.46	0.47	0.50	0.61	0.69	0.75	0.81	0.84			
Marquette, Mich	27			1.62														*			
Memphis, Tenn	18	9:46 a. m.	11:23 a. m.	0.69	10:04 a. m.	10:33 a. m.	0.11	0.14	0.22	0.27	0.36	0.44	0.51								
Meridian, Miss	11	1:40 p. m.	2:45 p. m.	1.11	1:46 p. m.	2:08 p. m.	0.01	0.42	0.73	0.91	1.04	1.07									
	23-24	8:15 p. m.	D. N. a. m.	1.87	10:18 p. m.	11:34 p. m.	0.19	0.15	0.26	0.37	0.50	0.62	0.79	0.92	0.98	1.04	1.14	1.23	1.55		
	29	10:07 a. m.	11:58 a. m.	0.95	10:20 a. m.	10:55 a. m.	0.01	0.08	0.25	0.40	0.43	0.61	0.70	0.77							
Miami, Fla	12	6:51 p. m.	8:55 p. m.	0.74	7:45 p. m.	7:57 p. m.	0.08	0.31	0.56	0.62											
Milwaukee, Wis	27			0.95														0.24			
Minneapolis, Minn	4			0.16														0.13			
Mobile, Ala	26-27	7:10 p. m.	D. N. a. m.	3.79	9:05 p. m.	9:55 p. m.	0.55	0.06	0.15	0.23	0.37	0.61	0.87	1.04	1.20	1.33	1.39				
					9:55 p. m.	10:45 p. m.		1.44	1.58	1.69	1.77	1.82	1.85	1.88	1.93	1.95	1.98				
					10:45 p. m.	11:35 p. m.		2.05	2.13	2.23	2.26	2.31	2.34	2.39	2.43	2.47	2.51				
					11:35 p. m.	12:09 a. m.		2.61	2.69	2.71	2.78	2.85	2.99	3.07							
Do	29-30	7:07 p. m.	5:25 a. m.	1.43	10:54 p. m.	11:45 p. m.	0.03	0.07	0.10	0.15	0.26	0.57	0.82	0.89	0.91	1.09	1.17	1.19			
Modena, Utah	3-4			0.47														0.08			
Montgomery, Ala	19	5:27 a. m.	10:07 a. m.	1.16	8:31 a. m.	8:51 a. m.	0.27	0.12	0.38	0.58	0.68										
Do	24	8:10 a. m.	10:20 a. m.	1.16	8:22 a. m.	9:09 a. m.	0.01	0.14	0.17	0.30	0.41	0.46	0.56	0.70	0.72	0.92	0.99				
Do	26	10:09 a. m.	1:05 p. m.	0.70	10:09 a. m.	10:23 a. m.	0.00	0.26	0.57	0.63											
Moorhead, Minn	22			0.30														0.23			
Mount Tamalpais, Cal	15			0.17														0.12			
Nantucket, Mass	31			0.77														0.51			
Nashville, Tenn	18			0.82														0.50			
New Haven, Conn	31			04.3														0.19			
New Orleans, La	27	D. N. a. m.	D. N. a. m.	0.86	3:20 a. m.	3:46 a. m.	0.04	0.15	0.33	0.51	0.67	0.77	0.81								
Do	29	6:00 p. m.	D. N. p. m.	4.03	6:27 p. m.	7:58 p. m.	0.08	0.14	0.30	0.67	1.04	1.24	1.49	1.68	1.78	1.88	2.05	2.68	3.37	3.72	
New York, N. Y	31			0.41														0.28			
Norfolk, Va	31			0.48														0.26			
Northfield, Vt	6			1.02														0.39			
North Head, Wash	4			0.65														0.19			
North Platte, Nebr	18			0.19														0.15			
Oklahoma, Okla	26			3.76														0.45			
Omaha, Nebr	10			1.41														0.58			
Oswego, N. Y	6			0.79														0.62			
Palestine, Tex	26			0.86														0.58			
Parkersburg, W. Va	28			0.57														0.37			
Pensacola, Fla	26	5:43 p. m.	7:50 p. m.	0.75	6:43 p. m.	7:02 p. m.	0.18	0.05	0.13	0.42	0.52										
Peoria, Ill	24			1.16														0.16			
Philadelphia, Pa	31			0.32														0.15			
Phoenix, Ariz	20			0.41														0.18			
Pierre, S. Dak	21			0.14														0.08			
Pittsburgh, Pa	6			0.29														0.18			
Pocatello, Idaho	6			0.42														0.26			
Point Reyes Light, Cal	16			0.19														0.19			
Port Angeles, Wash	27			0.70														0.17			
Port Huron, Mich	20			0.63														0.18			
Portland, Me	13			0.31														0.31			
Portland, Oreg	15			1.05														0.34			
Providence, R. I	1			0.20														0.10			
Pueblo, Colo	24			0.07														*			
Raleigh, N. C	30			0.23														0.19			
Rapid City, S. Dak	25			0.23														0.05			
Reading, Pa	6			0.27														0.17			
Red Bluff, Cal	2			0.28														0.14			
Reno, Nev	2			0.20														0.13			
Richmond, Va	31			0.30														0.23			
Rochester, N. Y	6			0.58														0.32			
Roseburg, Oreg	5			0.28														0.12			
Roswell, N. Mex	18			0.39														0.33			
Sacramento, Cal	5			0.31														0.10			
Saginaw, Mich	27			0.62														0.23			
St. Joseph, Mo	26			1.77														0.27			
St. Louis, Mo	27			0.94														0.39			
St. Paul, Minn	22			0.31														0.09			
Salt Lake City, Utah	17			0.42														0.31			
San Antonio, Tex	11			1.09														0.52			
San Diego, Cal	4			0.13														0.08			
Sand Key, Fla	18	8:17 a. m.	8:40 a. m.	0.52	8:20 a. m.	8:33 a. m.	0.01	0.19	0.44	0.50											
Sandusky, Ohio	28			0.44														0.27			
Sandy Hook, N. J	31			0.35														0.23			
San Francisco, Cal	16			0.03														0.03			
San Jose, Cal	5			0.11														0.05			
San Luis Obispo, Cal	1			0.78														0.59			
Santa Fe, N. Mex	20			0.85														0.48			
Sault Ste. Marie, Mich	4-5			1.50														*			
Savannah, Ga	30-31			0.60														0.46			
Scranton, Pa	30			0.81														0.49			
Seattle, Wash	6			0.25														0.15			
Sheridan, Wyo	23			0.18														0.07			
Shreveport, La	26			0.95														0.56			
Sioux City, Iowa	26-27			0.89														*			
Spokane, Wash	27			0.46														0.18			
Springfield, Ill	24			1.12														0.16			
Springfield, Mo	19			1.04														0.34			
Syracuse, N. Y	6			0.60														0.43			
Tacoma, Wash	26			0.71														0.20			
Tampa, Fla	21			0.59														0.54			
Tatoosh Island, Wash	11			1.16														0.47			

* Self-register not in use.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes or 0.80 in 1 hour, during October, 1918, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Taylor, Tex.	22	7:18 a. m.	9:55 a. m.	0.83	7:58 a. m.	8:15 a. m.	0.13	0.07	0.39	0.55	0.62										
	26	10:35 a. m.	1:30 p. m.	1.05	10:57 a. m.	11:27 a. m.	0.01	0.11	0.28	0.55	0.75	0.86	0.98								
Terre Haute, Ind.	27			0.68														0.59			
Thomasville, Ga.	30	10:50 a. m.	4:15 p. m.	1.05	2:05 p. m.	2:23 p. m.	0.23	0.24	0.27	0.42	0.55										
Toledo, Ohio	20			0.81														0.41			
Tonopah, Nev.	14			0.28														*			
Topeka, Kans.	7-8			0.66														0.37			
Trenton, N. J.	6			0.24														0.16			
Valentine, Nebr.	25			0.55														*			
Vicksburg, Miss.	9	D. N. a. m.	10:25 a. m.	4.65	1:54 a. m.	2:44 a. m.	0.18	0.16	0.25	0.34	0.48	0.59	0.65	0.71	0.77	0.84	0.88				
					2:44 a. m.	3:34 a. m.		0.91	0.94	0.97	1.01	1.07	1.13	1.23	1.31	1.41	1.48				
					3:34 a. m.	4:08 a. m.		1.55	1.64	1.75	1.81	1.87	1.93	1.99							
					5:38 a. m.	6:46 a. m.	2.72	0.09	0.13	0.15	0.20	0.36	0.48	0.58	0.68.	0.81	0.95	1.21	1.54		
	17	2:01 p. m.	D. N. p. m.	4.57	4:27 p. m.	5:27 p. m.	0.26	0.09	0.22	0.49	0.57	0.78	1.01	1.11	1.28	1.30	1.34	1.61			
					7:26 p. m.	9:10 p. m.	2.07	0.12	0.19	0.21	0.27	0.33	0.53	0.77	0.93	1.21	1.28	1.40	2.00	2.43	2.47
Walla Walla, Wash.	5			0.51														0.11			
Washington, D. C.	30			0.43														0.38			
Wausau, Wis.	27			0.87														0.33			
Wichita, Kans.	21-22			1.98														*			
Williston, N. Dak.	6			0.09														0.09			
Wilmington, N. C.	20-21			0.22														0.09			
Winnemucca, Nev.	14-15			0.22														*			
Wytheville, Va.	25			4.15														0.81			
Yankton, S. Dak.	25-26			0.55														*			
Yellowstone Park, Wyo.																					

* Self-register not in use.

TABLE III.—*Data furnished by the Canadian Meteorological Service, October, 1918.*

Stations.	Altitude above M. S. L.* Jan. 1, 1916.	Pressure.			Temperature.						Precipitation.		
		Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Feet.	Inches.	Inches.	Inches.	°F.	°F.	°F.	°F.	°F.	°F.	Inches.	Inches.	Inches
St. Johns, N. F.	125	30.00											
Sydney, C. B. I.	48	30.02	30.06	+0.10	49.2	+2.7	56.2	42.2	71	30	5.88	+1.19	
Halifax, N. S.	88												
Yarmouth, N. S.	65	30.00	30.07	+. 05	48.6	+1.0	55.1	42.1	65	29	4.85	+0.15	5 6
Charlottetown, P. E. I.	38	30.00	30.04	+ .08	47.4	+0.9	52.8	42.1	62	29	5.53	+0.63	
Chatham, N. B.	28	30.04	30.06	+ .10	46.0	+3.0	54.0	38.1	68	26	4.70	+0.84	T.
Father Point, Que.	20	30.01	30.03	+ .08	40.8	+1.0	47.9	33.7	59	22	1.21	−1.69	
Quebec, Que.	296	29.74	30.07	+ .07	44.3	+1.9	51.8	36.8	60	30	3.33	+0.18	1.7
Montreal, Que.	187	29.86	30.07	+ .06	47.5	+2.7	53.7	41.4	67	33	5.66	+2.53	
Stonecliffe, Ont.	489	29.44	30.05	+ .04	45.5	+2.7	54.1	36.9	70	28	3.86	+1.43	
Ottawa, Ont.	236	29.80	30.07	+ .06	48.0	+4.2	57.2	38.9	70	28	5.76	+3.21	
Kingston, Ont.	285	29.76	30.07	+ .04	50.2	+3.2	57.3	43.2	68	31	5.78	+3.05	
Toronto, Ont.	379	29.65	30.06	+ .02	51.4	+4.8	60.0	42.8	73	30	2.84	+0.48	
White River, Ont.	1,252	28.66	29.99	+ .01	39.2	+2.1	48.1	30.3	63	15	2.59	+0.24	T.
Port Stanley, Ont.	592	29.43	30.07	+ .02	51.4	+3.6	59.7	43.1	65	29	2.38	−0.60	
Southampton, Ont.	656	29.32			50.3	+4.2	58.2	42.5	71	28	2.56	−0.61	
Parry Sound, Ont.	688	29.35	30.05	+ .04	47.5	+3.6	55.1	40.0	64	26	4.43	+0.51	
Port Arthur, Ont.	644	29.28	29.99	+ .01	43.5	+3.6	51.0	36.0	68	28	2.51	−0.95	T.
Winnipeg, Man.	760	29.14	29.98	.00	44.0	+4.9	53.6	34.5	71	18	1.09	−0.61	3.0
Minnedosa, Man.	1,690	28.17	30.02	+ .05	41.8	+4.0	52.3	31.3	68	16	1.31	+0.11	0.2
Qu'Appelle, Sask.	2,115	27.68	29.94	− .03	43.6	+4.2	54.3	32.9	73	14	0.76	−0.34	0.2
Medicine Hat, Alberta	2,161	27.60	29.88	− .09	49.6	+4.8	64.2	35.0	80	13	0.18	−0.40	0.5
Swift Current, Sask.	2,440	27.33	29.90	− .07	46.1	+4.0	59.7	32.6	78	18	1.36	+0.48	0.8
Calgary, Alberta	3,389	26.36	29.89	− .06	47.6	+7.5	63.5	31.8	74	16	0.11	−0.37	0.2
Banff, Alberta	4,521	25.34	29.93	− .02	41.2	+1.9	49.9	32.6	63	19	1.05	+0.03	0.3
Edmonton, Alberta	2,150	27.57	29.86	− .07	42.3	+1.2	55.1	29.5	69	7	0.17	−0.53	0.5
Prince Albert, Sask.	1,432	28.35	29.92	− .05	41.6	+4.5	53.0	30.2	68	8	0.39	−0.44	0.4
Battleford, Sask.	1,592	28.16	29.91	− .06	42.9	+3.3	56.2	29.6	68	10	0.45	0.00	T.
Kamloops, B. C.	1,262												
Victoria, B. C.	228	29.79	30.05	+ .04	51.3	+2.1	56.4	46.2	66	40	4.13	+1.76	
Barkerville, B. C.	4,180												
Hamilton, Bermuda	151	29.96	30.12	+ .10	74.1	+1.1	79.3	68.9	85	64	2.88	−3.83	

* See explanation of tables in this REVIEW for Jan. 1918, p. 48.

Chart I. Hydrographs of Several Principal Rivers, October, 1918.

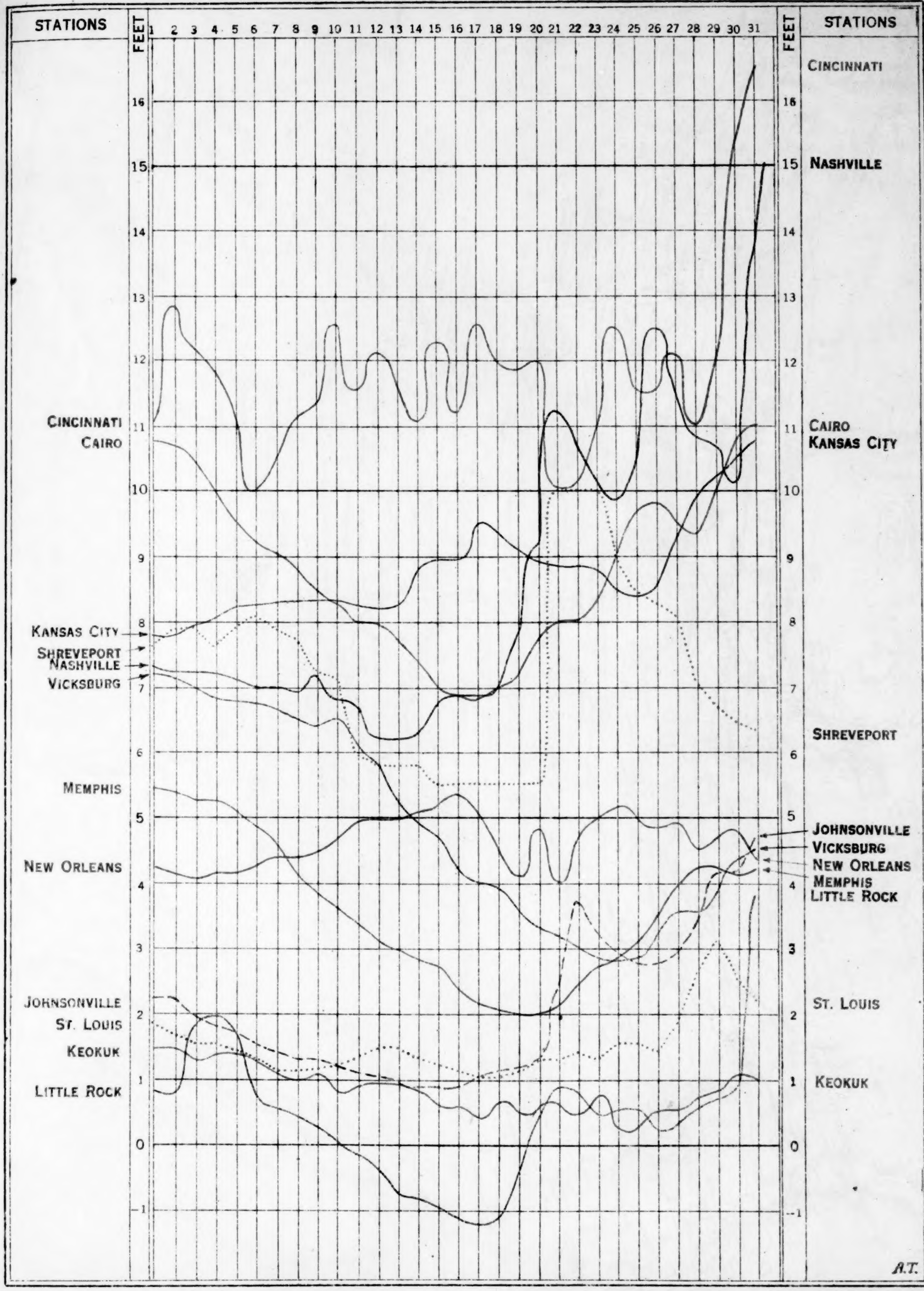


Chart II. Tracks of Centers of High Areas, October, 1918.

(Plotted by Charles A. Donnel.)

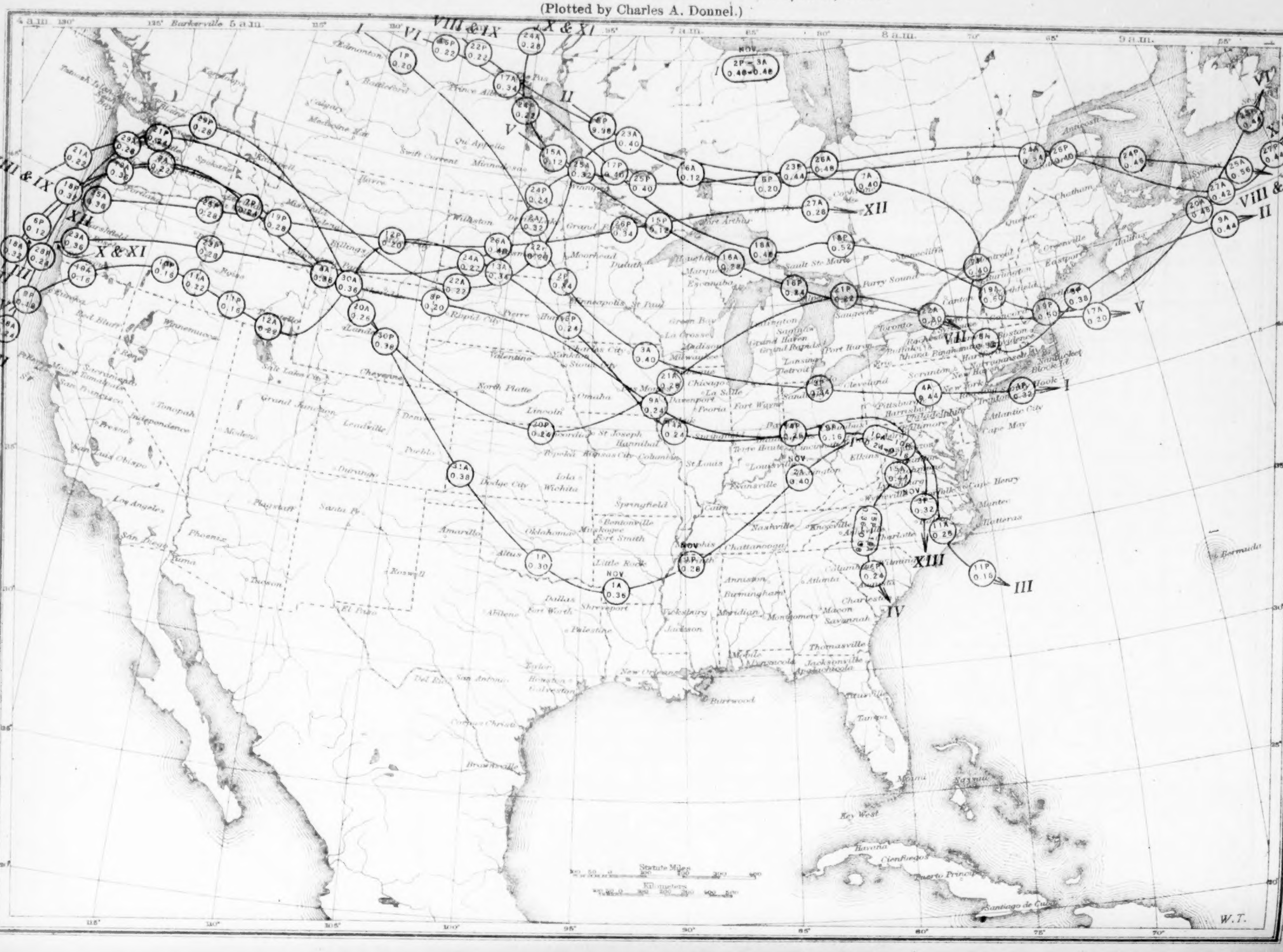


Chart III. Tracks of Centers of Low Areas, October, 1918.

Chart III. Tracks of Centers of Low Areas, October, 1918.
(Plotted by Charles A. Donnel.)

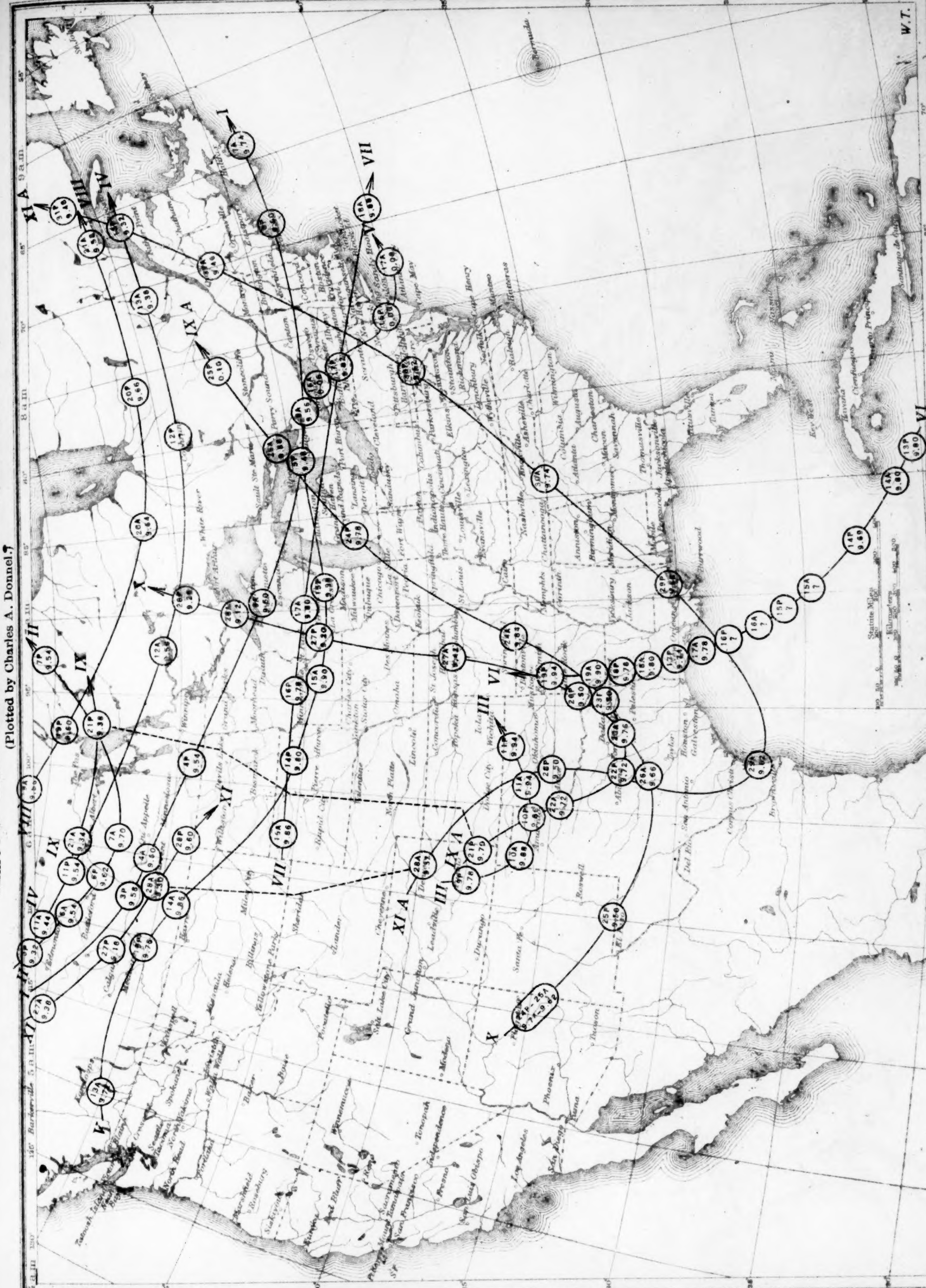


Chart IV. Departure (°F.) of the Mean Temperature from the Normal, October, 1918.

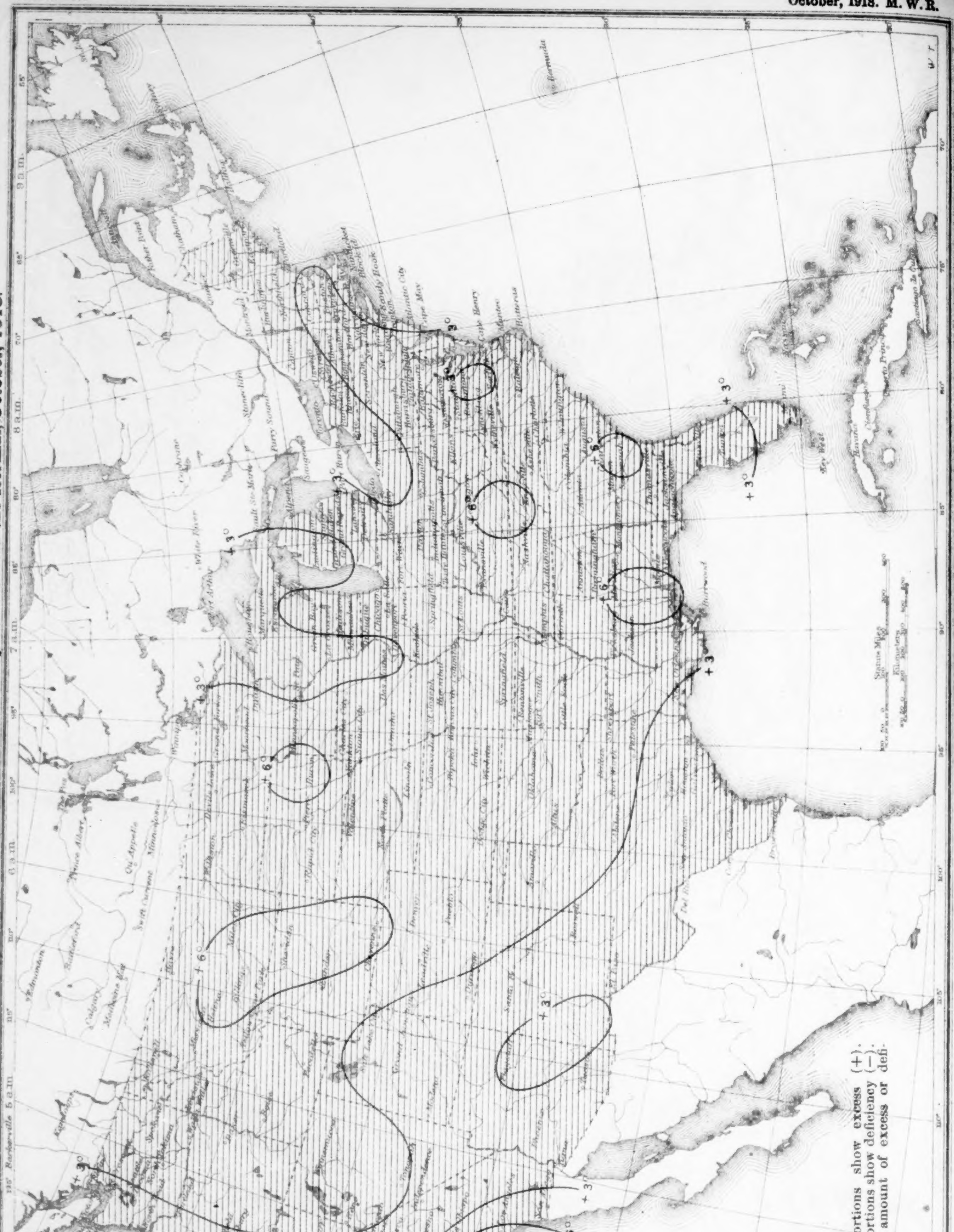


Chart V. Total Precipitation, Inches, October, 1918.

Chart V. Total Precipitation, Inches, October, 1918.

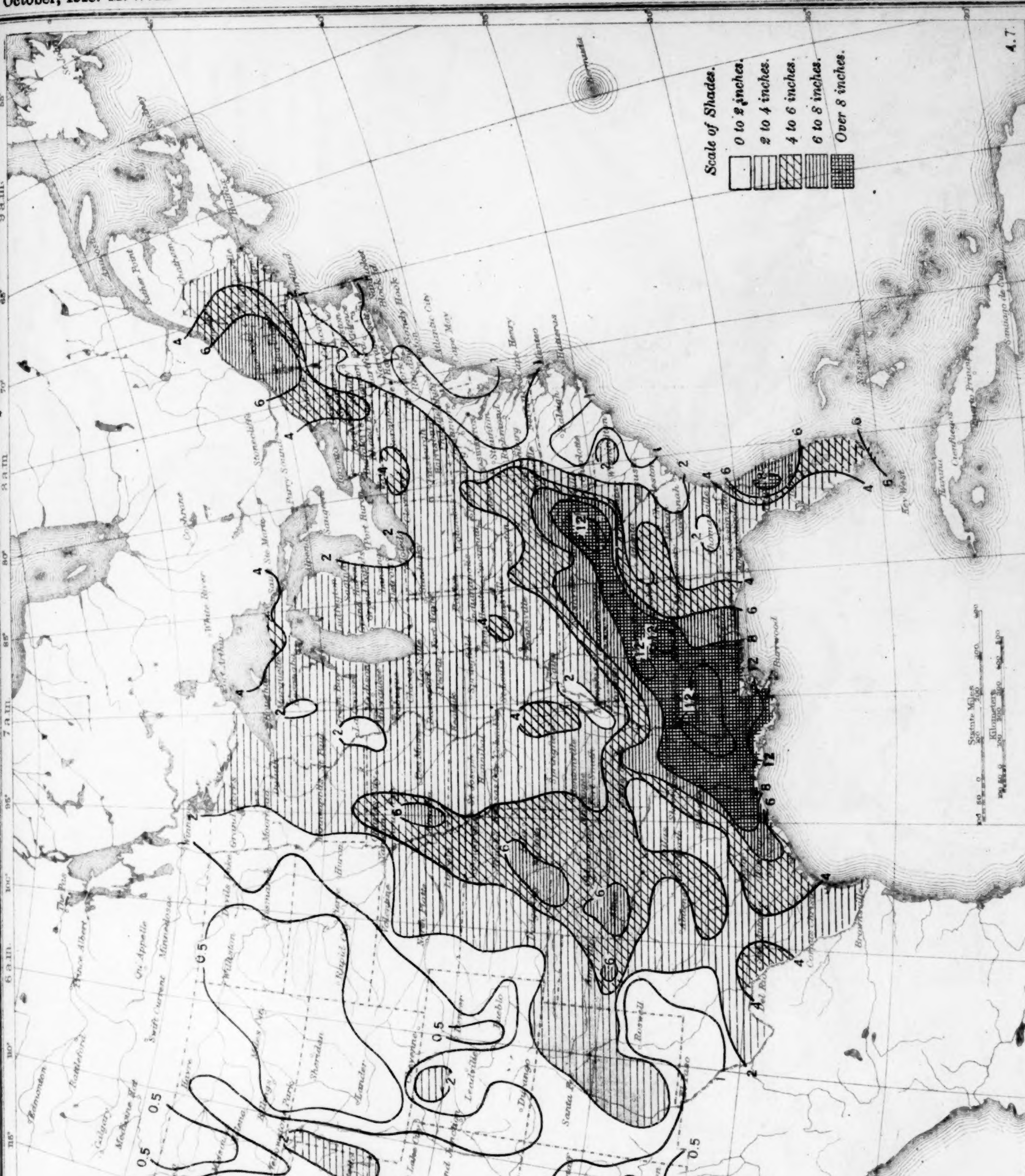


Chart VI. Percentage of Clear Sky between Sunrise and Sunset, October, 1918.

Chart VII. Isobars and Isotherms at Sealevel; Prevailing Winds, October, 1918.

Chart VII. Isobars and Isotherms at Sealevel; Prevailing Winds, October, 1918.

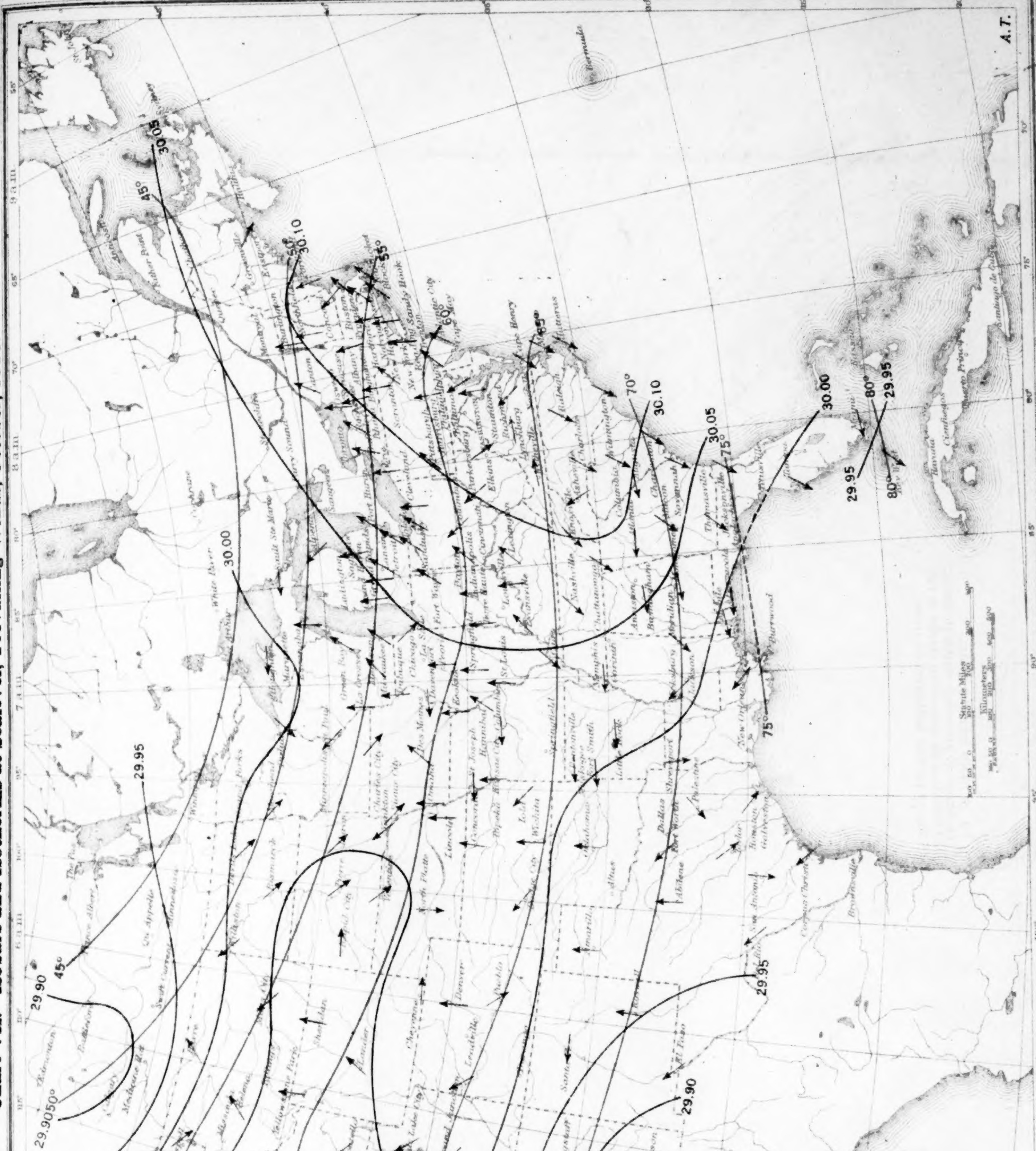


Chart IX. Means of Meteorological Data for North Atlantic Ocean, October, 1917.

(Plotted by F. A. Young.)